THE GLASS INDUSTRY
THE JOURNAL OF GLASS MANUFACTURING
VOLUME 42 NUMBER 9 SEPTEMBER, 1961

FACTS About Glass Mold Cleaning

by Kenneth Graham,

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All glass container companies have mold cleaning problems; what they are doing about them varies widely.

There are several different approaches to the problem of mold cleaning. Grit blasting and cleaning with acids and alkalis are currently most common. Newer methods, many of them proprietary and not yet fully evaluated by the industry, involve a combination of chemical processes with direct current, periodic reverse current, alternating current, and, most recently, ultrasonic devices.

Many manufacturers of pressed and blown glassware would welcome better cleaning processes than those now in use. What constitutes a better process, however, and how to prove it, are questions that have concerned the industry for years. As yet, there are no universal answers.

The chief difficulty is that the nature of the oxides and soil on glass molds will vary greatly depending on the mold metal, the glass composition, the days run without change, the type of glass molding machine, the type of mold lubricant, if any, and how the lubricant is applied. In view of this, the soil on glass molds will also vary within a given plant as well as from one plant to another. It may vary, too, in kind and degree from one shift to another because of differences in technique of individual operators.

Under these conditions, no one mold cleaning process will successfully remove all soils. Furthermore, a laboratory test on a few mold parts will not give a complete picture of the performance of a given process in production. Laboratory evaluation of processes may serve as a screening procedure, *i.e.*, for determining those showing potential value from those of little or no value. The best of these processes should then be run on mold parts taken directly from production—and for a long enough time with a sufficiently large number of pieces to give a true statistical picture of performance. Only then can the cost of operating the process be ascertained.

The cost of operating a process alone may be misleading. The life of a mold part will be much longer using a well chosen process than one which removes metal, roughens or pits the surface, changes dimensions, destroys detail in design or lettering, or plugs vent holes, all of which require costly repolishing and repair measures. The true cost of a mold cleaning process should therefore also include the changes in mold maintenance, repair, and replacement associated with its use.

By way of illustration, the experience of the Maryland Glass Co. may be cited.* Their plant has 18 I-S machines in continuous operation producing at the rate of 35 to 60 bottles per minute per machine. A normal run consists of 8 to 15 days but about 10 per cent of the production consists of longer runs of 30 or more days.

In 1957 Maryland Glass was cleaning molds by blasting with 220 angular steel, after which considerable polishing and refinishing was required. After proper testing of a proprietary chemical process† using periodic reverse current, it was decided to install the process. A consulting concern with experience in this field was given

* Published with permission of J. S. Heuisler, chairman of the board, Maryland Glass Co.
† Kelite, PR-Process 235.

the assignment of engineering the installation, total cost of which was $13,484.00 including engineering services.

The first full year of operation (1960) using PR-chemical cleaning gave an interesting cost comparison with the grit blasting method used in 1957, based upon plant engineering data.‡ Referring to Table I, the last column shows an increase of production of 12.6 per cent. In spite of this, the new mold cost increased only 0.7 per cent, the mold repair cost was 9.5 per cent less, and the total mold cleaning cost was 0.4 per cent lower, based upon 1960 labor rates for 1957 operation. The number of men required in 1960 decreased 27.2 per cent. The labor cost decreased 31 per cent, while overhead increased 1.4 per cent.

Table I

Cost Comparison of PR-Chemical Cleaning in 1960 with Grit Blasting in 1957 at Maryland Glass Co.

	1957	1960	Per Cent Change	Per Cent Adjusted for 1960*
1. Production, M gross	2,243	2,528	+ 12.6	+12.6
2. New Mold Cost, M$	75.16	92.02	+ 22.4	+ 0.7
3. Mold Repair Cost, M$	105.24	113.70	+ 8.0	− 9.5
4. Total Mold Cleaning Cost, M$	60.75	63.25	+ 4.4	− 0.4
a. Labor, men	11	8	− 27.2	−27.2
b. Labor cost, M$	46.67	38.50	− 17.4	−31.0
c. Overhead, M$	14.08	17.12	+ 21.5	+ 1.4
d. Chemicals, M$	—	7.64	+100.0	—
e. Grit, M$	0.76	—	−100.0	—

* 1957 figures by 1.20 = adjusted 1960 figures.

Note: Items 2, 3, 4a and 4b are largely labor costs and adjustment of 1957 figures for 20 per cent increase in labor rate apears justified.

A further comparison is presented in Table II based upon cleaning 778 mold parts per day with a total surface area of 800 sq. ft. The cost of cleaning by grit blasting compared to PR-chemical cleaning is 3.29¢ vs. 2.50¢/gross or 24.26¢ vs. 22.00 ¢/sq. ft., even though chemical cost was ten times the cost of grit employed.

Table II

Cost Comparison of PR-Chemical Cleaning in 1960 with Grit Blasting in 1957 at Maryland Glass Co.

	Grit Blasting, 1957*		PR-Chemical, 1960	
	¢/gross§	¢/sq.ft.	¢/gross§	¢/sq.ft.
Labor Cost	2.50	19.2	1.52	13.4
Overhead	0.76	5.8	0.68	5.95
Chemicals†	—	—	0.30	2.65
Grit‡	0.03	0.26	—	—
Total Cost	3.29	24.26	2.50	22.00

* Adjusted to 1960 labor rate.
† Kelite, PR-235 Process.
‡ No. 220 angular steel.
§ Based on production of 2,243,000 gross in 1957 and 2,528,000 gross in 1960.

These cost comparisons, while interesting, do not tell the whole story. The determining factor is: how adequately does the process, when properly carried out, clean the part and to what standard of quality? In the case of Maryland Glass Co., the particular PR-chemical process, as operated by them, cleaned their type of soil readily. Only mild hand swabbing with steel wool on selected areas of certain parts was necessary before final rinsing and drying.

Advantages claimed for the PR-chemical cleaning method over grit blasting are as follows:

1. Vents do not clog and do not require tedious cleaning.
2. Lettering does not blur.
3. Edges and corners do not round.
4. Cavity sizes do not change.
5. Surfaces do not pit or roughen.
6. All after-polishing is eliminated.
7. Mold life is increased.

A word of caution is necessary. No process will perform successfully if it is not carried out properly. This is especially true of processes involving the use of some form of current or ultrasonics as well as straight chemical cleaning. Experience has also shown that equipment for such processes, whether for an experimental or production line, must be engineered by someone experienced in these matters and properly installed to give satisfactory results. Valid conclusions with respect to different processes and their performance cannot otherwise be made.

Many existing mold cleaning operations can be improved with respect to both cleaning and possible savings. To explore the situation in a given plant, we recommend the following proven procedure.

1. As a screening operation, test a number of mold pieces with representative soil in a laboratory with adequate facilities, using the various available processes.

2. Determine what processes offer the most promise for handling the particular soil involved.

3. Install experimental or semiproduction equipment, properly engineered, in the plant.

4. Operate the equipment on production mold parts and collect the necessary data on which a decision can be made with respect to the best process, based on the indicated cost of operation and the quality of cleaning obtained.

5. Properly engineer any production mold cleaning installation to insure adequate capacity and successful operation.

A survey and analysis of the presently used mold cleaning process with respect to these factors will also be necessary as a proper basis of comparison.

The glass container industry alone produced 156,347,000 gross in 1960, according to the U. S. Department of Commerce report. Maryland Glass Co. production for 1960 was 2,524,000 gross. Their cost for new molds, repairs, maintenance and cleaning amounted to $268,970.00, equivalent to $106,400.00 per million gross. Based on this figure, the corresponding cost for the container industry as a whole would amount to $16,640,000.00 for 1960. The savings and advantages realized at Maryland Glass by finding the optimum cleaning process for their type of soil offer a great challenge to the glass industry as a whole.

‡ Furnished by R. A. Ott, plant engineer, Maryland Glass Co.

Great Moments in Glass

by Robert L. Nikirk,
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From the time that man-made glass vessels first appeared in Egypt about 3500 years ago, glass has lent itself to decorative techniques which complement its functional value and enhance its appearance. In this article, five objects from widely varying times and places have been chosen to illustrate the fact that glass decoration has always been closely linked to the particular properties of a specific formula.

Until the Seventeenth Century, the only commonly used formula for glass was what is now called "soda-lime." Even today, 90 per cent of the world's glass production each year is based on this formula. The raw materials for soda-lime glasses have been readily available to glassmakers throughout history. Soda-lime glasses are characterized by their particular ability to be worked into intricate shapes and their brittle hardness when cool. These were important factors in the spread of glassmaking throughout the Roman Empire after the invention of the blowpipe—perhaps the single most important technical discovery in the history of glass. This development probably took place in Syria some time in the First Century B.C. Thereafter, the use of the blowpipe for free-blown and mold-blown work permitted glass to be made faster and more cheaply than had ever before been possible—and in large quantities.

The number of Roman vessels found in archaeological excavations attests to the existence of a large industry based on the simple soda-lime formula. Common household items of this material are the direct ancestors of the lowly but indispensible glass vessels made today of soda-lima glass. Such familiar objects as tumblers, milk bottles, and light bulbs are related, from our viewpoint, to the bowls, flasks, and cosmetic containers of Roman times. Mass production was then the goal, even though in the Roman Empire glass manufacture was entirely by hand methods. Despite the enormous quantities of glass produced, however, obviously superior craftsmanship occasionally appears in these utilitarian Roman glass objects.

One of these many well-made, though common, vessels is the pitcher seen on the cover. Made in one of the Rhineland factories of the Third Century A.D., this finely proportioned object is an example of glassmaking skill utilizing the characteristic ductility of the Roman soda-lime glass. After blowing and shaping, threads were laid on the body while it was still hot, giving a slender elegance to the simple design. The typical Roman strap handle was varied by being folded several times where it joined the lip. The color of the pitcher (clear with a brownish-green cast) indicates that the ingredients of the glass were relatively impure, and crude potash, instead of the more common soda, was probably used as the alkali. The location of the Rhineland factories near large forests undoubtedly made potash a convenient raw material, and its use as a replacement for soda did not affect the extreme ductility of the glass. The ease of working was the indispensible factor in the making of objects such as the pitcher which depended on the deft manipulation of hot glass for successful completion.

Cristallo

Over a thousand years later, in the Fifteenth and Sixteenth Centuries, the leading glassmaking center of Venice continued to use a soda-lime formula. This was of a quality which led both Venetians and envious foreigners to distinguish it with the name of "cristallo," a flattering reference to the clarity of natural rock crystal. Venetian soda-lime glass contained silica, probably obtained from finely crushed quartz pebbles, and an alkali derived from the ash of sea and marsh plants. This mixture fused readily and, like the glass used by the Romans, lent itself to elaborate manipulation. Evidence of its skillful use in form and decoration is the covered dragon-stem goblet (Fig. 1) made in the late Sixteenth Century when Venice was one of the greatest commercial and artistic centers in Europe.

The dragon-stem goblet illustrates several decorative techniques which can be used when a craftsman has at his disposal a glass workable for elaborate shapes when hot, yet quick to cool. The pattern-molded foot, the threaded and twisted stem and finial, and the applied and tooled projections all contrast with the simplicity of the bowl and cover. The completed object is, as a result, an example of spectacular though tasteful craftsmanship.

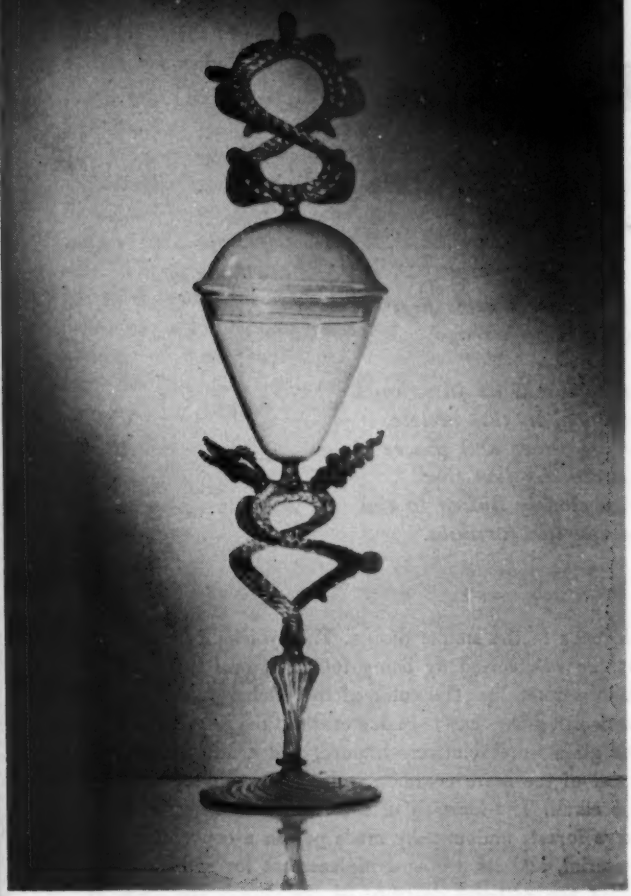

Photo courtesy Corning Museum of Glass.

The high quality of the Venetian glass formulas and their application in the making of glass objects was the envy of all Europe for two centuries. Venetian styles were imitated in Germany, the Netherlands, and France, giving a great impetus to the rapidly growing native industries which had been founded in the late Middle Ages in the North. Although the imitations eventually became indistinguishable from the Venetian prototypes, no advances were made in glass technology in Europe until the mid-Seventeenth Century, probably in Bohemia. In striving to surpass the Venetian cristallo and consciously working toward a material to equal the clarity of rock crystal, the experiments in Central European workshops evolved what is today termed "potash-chalk" glass. Potash, instead of soda, was used as a flux, and a large proportion of chalk was added. This produced an unusually fine clear glass. Its outstanding features, in addition to clarity, were brilliance and softness, ideal for wheel engraving. The decorative methods—cutting in relief and "intaglio" engraving—which had been learned from rock crystal engravers, were practiced with particular success on glass from Bohemia, Nuremburg, and Potsdam in the Seventeenth and Eighteenth Centuries. Intaglio, as does relief engraving, involves the pressing of a glass surface, with design sketched on, against a rapidly revolving abrasive-fed wheel of stone or copper.

(*Continued on page* 535)

Fig. 1 (above) shows the covered dragon-stem goblet produced in Venice in the late Sixteenth Century, a fine example of the elaborate decorative techniques possible with "cristallo" glass. Height 14 in. (35.6 cm). Fig. 2a (right) and 2b (detail, below) illustrate the art of "intaglio" engraving practiced on "potash-chalk" glass. The goblet, engraved with hunting scene, was produced in Nuremburg, Germany, during the late Seventeenth Century. Height 11¼ in. (28.5 cm).

Photo courtesy Corning Museum of Glass.

Photo courtesy Corning Museum of Glass.

Photo courtesy Corning Museum of Glass.

Fig. 3 (right) is typical of the products made by George Ravenscroft after his "lead glass" formula was put into regular production. This goblet was made by his Savoy Glasshouse in London, England, about 1676-78. Height 7-5/16 in. (18.5 cm). Fig. 4 (below) represents Irish cut lead glass at its best, displaying the high light refraction index possible when the technique of cutting was applied to Ravenscroft's glass. Variations of his formula are still used as the basis for "crystal" glass. The cut glass sweetmeat dish was produced in Ireland ca. 1775-80. Height 4-9/16 in. (11.6 cm).

Photo courtesy Corning Museum of Glass.

American Scientific
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The following papers, to be reviewed here in two parts, were heard by the Society at its 6th Symposium earlier this year in New York City. Of the many papers delivered there, the majority dealt with electron tube research because it is in this field that the greatest changes are taking place.

Alumino Silicate Glasses

By F. L. Bishop, Kimble Glass Co.

In recent years, a new class of glass compositions has appeared—the alumino silicates. Generally speaking, these glasses are basically silica, with close to 20 per cent alumina and the balance mostly lime and magnesia.

For some years Kimble has been producing EE-2 glass, the basic composition of the group of alumino silicate glasses. It is essentially an alkali- and boron-free material consisting only of oxides of silicon, alumina; calcium, and magnesium. There are, of course, traces of soda and other elements inherent in raw materials or in furnace melting of glass, but these are extremely minor in quantity. It is well known that EE-2 seals to molybdenum, but these alumino silicates now include glasses for sealing to several other materials such as alumina and tantalum. There is also an EE-4 glass which has practically the same physical properties as EE-2. The former, however, contains some cerium which reduces the amount of browning from electron or X-ray sources.

There are many reasons for using the alumino-silicate family of glasses, among them, its high-temperature service. EE-2, having an annealing point of 755°C (1392°F), can actually be used in the form of a tube under vacuum at temperatures well above 700°C. Some other forms of alumino-silicates can be used up to 150°C higher.

Another outstanding feature of the alumino silicates is the low gas permeability. In combination with this characteristic, the high-temperature properties of the glass enable one to bake out electronic tubes and other items at temperatures approaching 750°C. As a result, the gas evolution from metal parts in the tube are reduced much more than with other glasses where 450°C to 400°C is the standard bake-out range. In addition to the gases given off by metal and glass parts during operation of electron tubes, there are frequently constituents of the glass which evolve either because of electron bombardment or because of high temperatures. Also, in the sealing of glass parts it is necessary to make the seals carefully and uniformly, or more volatile constituents will come from the glass to change its characteristics around the seal. This then leaves stresses in the seals.

The alumino silicate glasses, on the other hand, do not have any volatile constituents, except that when heated to high temperatures, all of the constituents tend to volatilize very nearly at the same time. Thus, in the case of alumino silicates, the glass may be exposed to sealing temperature for as long as an hour and still seal consistently to another piece which is just freshly heated. The original purpose of the EE-2 glass was its use in neutron fields where, in ordinary glass, the neutrons are absorbed by such items as boron and cause destruction of the glass materials. The alumino silicates have an extremely low cross section for neutrons and, thus, can be used where other glass would disintegrate. EE-4 is also stabilized against damage by electrons or X-ray and Gamma rays. Therefore, wherever atomic radiation is a problem, EE-4 should be specified.

Finally, the chemical durability and weathering resistance of the alumino silicates are outstandingly good. These glasses are the equivalent of the glasses normally used for chemical service and durability, and can be softened for such glasses, particularly where radiation fields may be a problem.

Techniques for Laboratory Working of Alumino-Silicate Glasses

By J. F. Barbour, H. W. Benson, F. M. Collins, and D. J. Jansen, Linfield Research Institute, McMinnville, Ore. Collins is now at Field Emission Corp., McMinnville, Ore.

The alumino-silicate glasses offer unique properties, and consequently are finding increasing use as electron tube envelopes and in ultrahigh vacuum work. The combination of low coefficient of thermal expansion, high softening temperature, good electrical properties, low rate of

diffusion of atmospheric gases, and the ability to withstand considerable power loadings without seriously degrading vacuum would certainly lead to the more rapid and widespread acceptance of this class of glasses if they were readily workable by conventional and familiar techniques. These glasses have been extensively used in the laboratory for a number of years because of the exceptionally severe demands for ultrahigh vacuum conditions imposed by the sensitivity of field emission cathodes to contamination and sputtering. While considerable difficulty was experienced during initial attempts, these glasses are now routinely worked by both flame and induction heating techniques.

The following general steps for working alumino-silicate glass are recommended.

1. All pieces of glass should be cleaned inside and out with alcohol or acetone.
2. After chucking in the lathe, portions of the glass to be heated should be wiped off again as a final precaution against fingerprints.
3. Larger sizes of glass should be preheated, using a gas-air annealing burner, until the glass shows a golden color.
4. Following pre-heating, the lathe burners should be lit starting with pure hydrogen, and oxygen added slowly until the working temperature of the glass is reached.

Care should be taken to have a bushy hydrogen flame and to add the oxygen slowly. Smaller glass sizes, 1 in. OD or less, do not require the gas-air flame preheating. Oxygen (the minimum amount to give sufficient heat for working the glass) is added. When moving to a new area, even though it be adjacent to the previously worked, area, the same preheating procedure is followed; that is, a bushy hydrogen flame is used and oxygen is added slowly until the working temperature is reached. Corning 1720 glass will reduce or darken slightly, but not enough to cause difficulties. All 1720 glassware is flame-annealed with the gas-air burner, or placed in a preheated oven and annealed at 720°C.

Corning 1723 and Kimble EE-2 glasses present more problems in flame working because they tend to reduce so badly that transparency is affected when they are worked with a highly reducing flame. The only successful way found to work these glasses without causing severe reduction is to preheat with a highly reducing hydrogen-oxygen flame until the glass starts to reduce or darken; then enough oxygen is added to cease reduction and restore transparency. The glass can then be worked without causing reboil or reduction. Here the mixture is much more critical; not enough oxygen causes reduction, and too much causes reboil.

Molybdenum is used to seal to alumino-silicate glasses because it yields an adequate match of average expansion coefficients between annealing and room temperature. Usually it is nickle-plated to prevent excessive oxidation. Generally, 0.050-in. leads or pins are used, and these are wetted with a thin alumino-silicate glass bead before electroplating.

Because induction heating techniques permit greater control of the atmospheric environment, they are useful in a number of operations which would be difficult or impossible by flame working. Among the items fabricated from alumino-silicate glass by this technique are tubular metal-to-glass seals, fritted headers, microwave windows, tubular disc seals, and complete stacked-element tubes.

Properties and Applications of Devitrifying Solder Glasses

By Francis W. Martin and Frank Zimmar, Corning Glass Works, Corning, N. Y. Presented by Martin.

Typical characteristics of devitrifying solder glasses were discussed, as follows, with emphasis on the specific advantages and disadvantages relating to the stable solder glasses.

1. Greater rigidity at high temperatures after sealing. This is the principal feature of the No. 95 Pyroceram Brand cement in the color TV tube application. Here sealing is at 440°C and subsequently exhaust bake is as high as 420°C with no relative movement of the parts.
2. Lower effective expansion for a given temperature. With stable solder glasses it is always true that a lower effective expansion can be obtained only at the price of an increased sealing temperature. Some reversal of this tendency is obtained by using devitrifying solder glasses.
3. Expansion characteristics may be more desirable. For instance, in some cases it is possible to maintain a compression stress in the solder glass at all temperatures between the sealing and room temperature. This is not possible with stable solder glasses because contraction in the setting-up region is always higher than that of bodies being sealed.

4. Lower fillet stresses. This is one of the less obvious advantages. Fillet stresses are those stresses that are brought about by visious displacements in the solder glass during the cooling cycle in response to forces produced by differential contraction between the sealing glass and bodies being sealed.

The following limitations of devitrifying solder were pointed out.

1. Sufficient flow for good seal formation is sometimes hard to obtain. All the flow for good seal making and for developing an adherent bond to materials being sealed takes place early in the sealing cycle before the solder glass sets up enough to impede visious flow. Poor flow cannot be counteracted by merely increasing the sealing temperature; this will usually bring about a faster devitrification and, therefore, little or no net gain.

2. Glass quality control is considerably more difficult than with stable solder glasses. Not only is the composition more critical, but there are also greater possible variations in properties due to melting conditions, quenching methods, state of grind, contamination, and weathering of the powdered glass.

3. Sometimes it is advantageous to preglaze parts to be joined. With devitrifying solder glasses there is only a narrow range for sintering before the onset of devitrification, so close temperature control is necessary.

4. Sealing is limited to powder glass methods. Former particle boundaries in the sintered glass serve as nuclei for crystal growth. Massive glass applied as preformed cane or sheet does not devitrify in a uniform manner.

Metal Diffusion Techniques and Glass Sealing Problems in the Electron Tube Industry

By Richard Wachtell, Chromalloy Corp., and *H. W. Leighton,* Electron Technology, Inc.

There are three major physical considerations in the development of sound, vacuum-tight metal-to-glass seals. The first, and possibly major factor, is a proper match of the coefficient of thermal expansion of the metal joint, or interface, between the glass and the metal comportion to the glass. The second is the soundness of the joint. The third factor is seal geometry.

Control of the coefficient of expansion of glass sealing alloys is achieved by close control of alloy chemistry, and appropriate alloy-glass combinations have been worked out over a period of years. Unfortunately, alloys having optimum expansion characteristics are sometimes difficult to seal because of poor surface properties which develop a weak glass-to-metal interface. It has long been recognized that chromium oxides form excellent bonds with glass. When a high chromium content exists in the metal to be sealed, oxide surfaces are readily obtained by controlled oxidation of the metal as a preparatory step. Thus, the chromium ferritic group of the 400 series stainless steels can readily be treated to form oxide surfaces which are coherent and firmly attached to the base metal, and which also form excellent bonds with appropriate glasses.

Other common sealing alloys, such as Kovar, which do not contain chromium but may be treated by the Chromallizing process, are vastly more difficult to prepare in a manner that will produce the desired oxide on the surface. The result is a penalty paid either in unreliability of the seal formed, or high cost for elaborate and closely controlled preparatory steps.

With materials such as molybdenum and tungsten, some of the oxides formed are volatile and sealing may have to be conducted under protected atmospheres, in sheaths or the like.

The heart of the Chromallizing process is a surface alloying of the metal to be sealed with chromium. A thin layer is deposited. Thick layers, when oxidized to form the bonding surface, would diffuse sufficiently into the base metal to alter its chemistry and, hence, its expansion characteristics, causing a mismatch with the glass. The high surface chromium content makes oxidation a routine and simple treatment and permits even molybdenum and tungsten to be sealed in open air.

The strength of the seals developed is extremely high, permitting the use of some unorthodox material combinations. Thus, Chromallized tungsten has been sealed direct to Pyrex.

A Solder Glass Sealed Vacuum Envelope To Operate at 500°C Ambient Temperature

By Hilmar M. Heyn and Kenneth L. Rohrer, Electronic Tube Div., Westinghouse Electric Corp., Elmira, N. Y.

In the last few years considerable effort has been made on the evaluation of Corning's No. 9606 Pyroceram as an envelope material which could serve in the same application where ceramics are used.

Direct-flame seals from No. 9606 Pyroceram tubing to No. 1720 alumino silicate glass and Corning's No. 7720 glass were fabricated experimentally for the system to test the permeability of Pyroceram. The seals, approximately 1 in. in diameter, withstood the many heating and cooling cycles demanded without failure.

Tungsten leads up to 0.030 in. in diameter have been found to make satisfactory seals throughout the temperature range with No. 9606 Pyroceram. Tungsten must be properly prepared to resist oxidation at elevated temperatures. Molybdenum should also be applicable in some products, but its poor resistance to oxidation must be overcome. Chromizing may be a process which could very well overcome the oxidation difficulties of molybdenum.

For joining No. 9606 Pyroceram to itself and tungsten, No. 45 Pyroceram cement is a satisfactory medium. This provides a vacuum-tight envelope which can be processed at high temperatures (750°C bake-out), and also operated for extended periods at high temperature. Work in this field, especially at high temperatures, will be continued at Westinghouse with the development of a triode of suitable characteristics.

The problem of the selection and preparation of suitable lead wires was studied, and electroplating and vapor-phase coating methods of application chosen for

consideration. The principal advantage of these methods lies in their ability to limit the barrier to a thin layer of rather high density.

Vapor-phase coatings were deposited on molybdenum and tungsten to form diffusion layers of silicides. Tungsten was so severly embrittled as to render it useless; it could not be bent without breaking. Molybdenum did not appreciably embrittle. Treated tungsten was badly oxidized ofter exposure for 24 hours at 600°C in air. Treated molybdenum showed only traces of oxidation after the same exposure. No seals in envelopes were made with silicided molybdenum. Limited tests with sealed chromized tungsten leads were unsuccessful because of initially leaky seals.

Electroplated gold and platinum on tungsten were selected for evaluation. Gold is unique in that it forms no oxide at any temperature. Platinum does not undergo rapid oxidation until 1620°C, but has, at times, been suspected to be fairly permeable to air. The rate of diffusion of oxygen through gold is believed to be very low. Platinum-plated tungsten yielded initially leaky seals, and further testing was discontinued.

A 0.1-mil electroplated layer of gold on tungsten proved to be a very effective barrier layer. Gold deposited on, and diffused into, a very thin nickle strike layer was less effective for oxidation prevention and gave, for the most part, initially leaky seals. As expected, accelerated oxidation tests at 700°C with 0.1 to 0.8 mil of gold revealed that oxidation resistance increases as the thickness of the electrodeposit is increased. Because the thermal expansion of gold is 142 by 10^{-7} in./in./°C, it was deemed necessary to minimize possible deleterious expansion effects by evaluating 0.1 mil deposits.

Further oxidation resistance was gained by application and sintering of thin layers of potassium silicate or borax to gold-plated tungsten. The value of these applications was clearly demonstrated with unsealed leads by oxidation tests at 700°C, but no detectable evidence of resistance of leads sealed into vacuum envelopes was noted after environmental tests at 500°C.

Glass-to-Metal vs. Ceramic-to-Metal Envelopes for Electron Tubes

By Gerald W. Karlsruher, General Telephone and Electronics Lab. Inc., Bayside, N. Y.

The problems that a tube designer should consider before deciding what type of construction to specify are many and varied. Glass is a strong and reliable material. The glass envelope also allows visual inspection of the internal tube structure, an invaluable aid in trouble shooting. Corrective action can often be taken without cutting open the tube envelope. Another advantage of glass-to-metal envelopes is that strains can be analyzed with a polariscope. Ceramic-to-metal envelopes, on the other hand, do not permit visual inspection of the electrodes. although X-ray analysis of such tubes can sometimes prove to be beneficial. Another obvious disadvantage of ceramic-to-metal tubes is the impossibility of measuring strains in seal areas. Therefore, greater emphasis must be placed on the seal designs to minimize the chance of seal failures.

Resistance to shock and mechanical vibration are important for military applications. There is no doubt that for large structures glass is often eliminated from consideration because of its inability to withstand severe mechanical shock. However, if the internal structure of the tube is designed correctly and the tube is properly shock-mounted, glass can be as effective as a ceramic-to-metal envelope in resisting shock and vibration. The particular envelope material used has, in most cases, little effect on the operation of the device.

The thermal shock resistance of glass is relatively poor, however, and for this reason many tube designers prefer to use ceramic-to-metal envelopes where the tubes must withstand high ambient temperatures.

Resistance to radiation is another important consideration in certain applications, and one that is assuming increased importance. Studies have shown that glass tubes become gassy or discolored when exposed to thermal neutrons of the order of 10^{16} units of integrated thermal flux (nvt). Apparently, the boron in many glasses absorbs the thermal neutrons and this changes the properties and structure of the glass. This difficulty can be eliminated by manufacturing tubes from boron-free alumino-silicate glasses, such as Kimbal type EE-2, or Corning 1715. Such tubes are able to withstand thermal neutrons of the order of 10^{16} nvt without cracking, gassing, or discoloring.

The fact that refractory metals such as molybdenum and tungsten can be sealed to alumino-silicate glass causes some surprise for two reasons: *(1)* the metals oxidize rapidly at elevated temperatures, and *(2)* it is difficult to weld internal tube components to these metals. Oxidation can be prevented by the pack-chrome diffusion processes mentioned earlier. This Chromallizing provides a protective chrome-rich surface which is then oxidized in wet hydrogen at about 1100°C. The oxidized chromium surface provides adequate oxygen resistance for direct flame sealing at 1200°C to 1300°C, and also for extended high-temperature bake-out.

Low-Temperature Solder Glasses in the Electron Tube Industry

By J. L. Gallup

For a number of years, glasses with low-temperature softening ranges (600°C and below) have been used in the electronics industry to join glass parts to each other, to metal parts, and to ceramic parts at temperatures previously used only for metal solder seals. Hence, these glass sealing materials are called "solder glasses."

The low-melting glass compositions considered are shown in Table I (page 504).

Viscosity measurements were made at several temperatures corresponding to viscosities in the range from $10^{9.5}$ to $10^{13.5}$ poises. The results are shown in Table II.

Thermal expansion measurements were made in an automatic dilatometer of the quartz-expansion-furnace type.

Table III shows the values calculated for the compositions considered. Glasses 2, 3, and 5 have been used as the cementing agent in permanent marking inks stamped on bulb walls of soft glass electron tubes having thermal expansion coefficients of about 90 by 10^{-7} in./in./°C. The lack of difficulty in using these three inks makes it appear that coefficient of thermal expansion is not critical for solder glasses applied in thin layers over limited areas.

Glasses 6 and 7 have been used to seal 0120 glass stems to cold-rolled steel shells. Glass 7 provided a better match and gave better results. Glass 6 has been used in sealing mica to 0080 or 0120 glass bulbs and to steel shells. Glasses similar to 6 have proven valuable in sealing lime glass diaphragms to chrome iron rings where close expansion matches were necessary.

Solder glasses such as these have been, and can be, applied to many sealing situations in the electron tube industry. However, their primary advantage is their low softening temperature and hence, the relatively low temperature at which vacuum-tight seals can be made. Such low sealing temperatures are primarily valuable in situations where metal parts are close to the seal area and likely to be deformed or oxidized by the heat required to seal the normal standard glasses.

Solder glasses are usually applied in powder form, either as a dry powder sifted on a hot metal part or as a liquid suspension painted on the parts to be joined and subsequently heated to fuse the powder. If the dry powder technique is employed, the powder is used in carefully sized range, usually 40 to 100 mesh material, in order to avoid the possibility of producing a toxic air-floated dust.

When a liquid suspension is used, the powder is ground finely in a ball mill (200 mesh or finer) in a liquid such as methanol or water. The resulting suspension can be applied by brushing or spraying. If the particles have been ground down to contain many particles in the ½-micron range, the suspension will settle very slowly. Otherwise, it will have to be stirred repeatedly since the high density (five to seven times that of water) causes large particles to settle rapidly. The small particles in the ½-micron range are kept in suspension by Brownian movement.

(*Continued on page* 536)

TABLE 1

Compositions—Per Cent by Weight

No.	PbO Chem.	PbO Batch	B_2O_3 Chem.	B_2O_3 Batch	SiO_2 Chem.	SiO_2 Batch
1	71.4	71.3			28.6*	28.7
2	84.8	84.7			15.2*	15.3
3	76.3	76.2	23.7*	23.8		
4	82.8	82.7	17.2*	17.3		
5	88.3	88.0	11.7*	12.0		
6	71.9	72.0	14.2*	14.0	13.9	14.0
7	85.1	85.0		7.5		7.5

*By difference.

TABLE II

Viscosity Data—(Poises)

Composition Mole Per Cent	$10^{7.6}$* Softening Point (°C)	$10^{13.4}$ Annealing Point (°C)	$10^{14.6}$* Strain Point (°C)	10^9 (°C)	10^{10} (°C)	10^{11} (°C)	10^{12} (°C)
40 PbO, 60 SiO_2	568	444.0	421.5	535.5	512.0	490.5	471.0
60 PbO, 40 SiO_2	429	375.5	344.5	410.0	397.0	384.5	373.0
50 PbO, 50 B_2O_3	435	376.5	365.5	419.0	408.5	398.0	389.0
60 PbO, 40 B_2O_3	383	327.0	317.0	368.0	357.5	348.0	339.5
69.5 PbO, 30.5 B_2O_3	330	281.5	272.5	317.0	308.0	300.0	292.0
42.7 PbO, 26.5 B_2O_3, 30.8 SiO_2	477	406.5	393.5	458.5	445.0	433.0	421.5
62 PbO, 17.6 B_2O_3, 20.4 SiO_2	371	311.0	300.0	355.0	344.5	333.5	324.0

*Extrapolated from measured values.

TABLE III

Coefficient of Thermal Expansion of High Lead Solder Glasses

Glasses	Composition Mole Per Cent	Composition Weight Per Cent	Coefficient of Thermal Expansion 30° to 300°C
1	40 PbO.60 SiO_2	71.3 PbO, 28.7 SiO_2	74 by 10^{-7} in./in./°C
2	60 PbO.40 SiO_2	84.7 PbO, 15.3 SiO_2	108 by 10^{-7}
3	50 PbO.50 B_2O_3	76.2 PbO, 23.8 B_2O_3	93 by 10^{-7}
4	60 PbO.40 B_2O_3	82.7 PbO, 17.3 B_2O_3	108 by 10^{-7}
5	69.5 PbO.30.5 B_2O_3	88 PbO, 12 B_2O_3	124 by 10^{-7} (only to 280° C)
6	42.7 PbO.26.5 B_2O_3.30.8 SiO_2	72 PbO, 14 B_2O_3, 14 SiO_2	85 by 10^{-7}
7	62 PbO.17.6 B_2O_3.20.4 SiO_2	85 PbO, 7.5 B_2O_3, 7.5 SiO_2	117 by 10^{-7}

ACS GLASS DIVISION

Fall Meeting

October 11-13, 1961

Bedford Springs, Pa.

Fifteen papers will be presented in three half-day technical sessions at this year's annual meeting. A Friday morning and afternoon workshop, organized by Frank R. Bacon, Owens-Illinois Technical Center, Toledo, O., will also be featured. Serving with Dr. H. E. Simpson, program committee chairman, are Charles L. McKinnis and Joseph L. Rood.

SESSION I: Thursday Morning, October 12, 9:00 A. M. H. E. Simpson, College of Ceramics, Alfred University — Chairman

Method of Measuring Electrical Conductivity vs. Temperature for Refractories for All-Electric Glass Furnaces
LARRY PENBERTHY and HOWARD HARRIS, Penberthy Electromelt Co., Seattle, Wash.

X-Ray Absorption Fine Structure of Glasses
W. F. NELSON, I. SIEGEL, and R. WAGNER, Fundamental Research Section, General Research Div., Owens-Illinois Technical Center, Toledo, O.

Ed.—Copy recd Aug 16.
Controlled Potential Coulometry of Lead, Cadmium, and Zinc in Glasses
F. R. SEGATTO, Research and Development Div., Corning Glass Works, Corning, N. Y.

Properties of Alumino-Borate Glasses of Group II Metal Oxides — Electrical Properties
CHIKARA HIRAYAMA, Westinghouse Materials Lab., Pittsburgh, Pa.

Glass Division Business Meeting: 11:00 A. M.
J. R. HENSLER, presiding.

ASTM Luncheon Meeting: 12:00 Noon

SESSION II: Friday Morning, October 13, 9:00 A. M. C. L. McKinnis, Owens-Corning Fiberglas Corp. — Chairman

A Simplified Thermal Expansion Apparatus
E. H. FONTANA, Research and Development Div., Corning Glass Works, Corning, N. Y.

The Chemical Durability of Arsenic Sulphide Glasses
FRANCIS C. LIN and SHIH-MING HO, Materials Lab., Westinghouse Electric Corp., Pittsburgh, Pa.

The Electrochemical Determination of the Ferric-to-Ferrous Ratio in Soda-Lime Glasses
M. B. BLINN, Glass Research Center, Pittsburgh Plate Glass Co., Pittsburgh, Pa.

Fiber Glass — History and Prognosis
ALEXANDER SILVERMAN, University of Pittsburgh, Pittsburgh, Pa.

National Academy of Sciences. National Research Council — Advisory Panel to the National Bureau of Standards, Mineral Products Div.: 11:00 A. M.
J. R. HENSLER presiding. Comments and report by KARL SCHWARTZWALDER, The American Ceramic Society, Inc., NORBERT J. KREIDL, The Glass Division, and A. D. FRANKLIN, The National Bureau of Standards.

SESSION III: Friday Afternoon, October 13, 2:00 P. M.

Constitution of Mixed-Alkali Phosphate Glasses—Constitution of Lithium-Rubidium Phosphate Glasses
M. K. MURTHY and A. E. R. WESTMAN, Ontario Research Foundation, Toronto, Canada.

Sliding Friction and Related Surface Damage
R. D. SOUTHWICK, American Glass Research, Inc., Butler, Pa.

The Dual Role of Titanium in the System SiO_2.K_2O.TiO_2
BH. V. JANAKIRAMA RAO, International Resistance Co., Philadelphia, Pa.

Glass Formation and Properties of Glasses in Ternary Alkaline Earth Borosilicate Systems
BH. V. JANAKIRAMA RAO, International Resistance Co., Philadelphia, Pa.

Mixing in Glass Tanks
ALFRED R. COOPER, JR., Ceramics Div., Massachusetts Institute of Technology, Cambridge, Mass.

Dry Air System for the Glass Industry
R. C. COBLENTZ, Lynch Corp., Anderson, Ind.

WORKSHOP: Friday Morning and Afternoon, October 13. F. R. Bacon, Owens-Illinois Technical Center — Chairman

Techniques of Chemical Durability Measurement
H. E. SIMPSON, opening remarks.

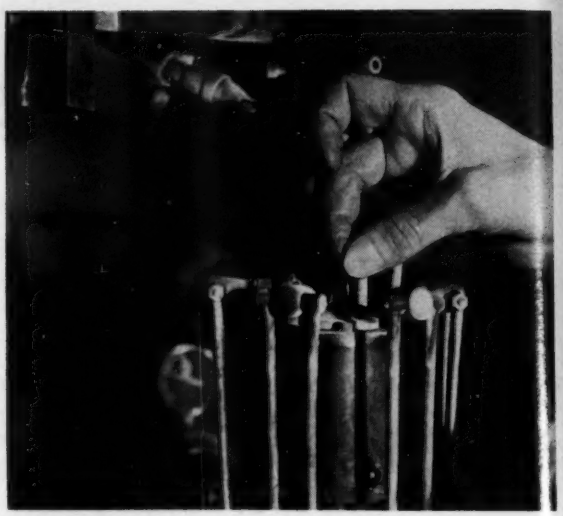
Elements of Testing
Preparation of leaching medium.
Preparation of glass sample.
Construction and operation of thermostat.
Evaluation of attack.

Discussion of Complete Procedures
Crushed-sample tests.
Bottle-surface tests.
Other tests.

Panel Members

P. BRUCE ADAMS, Corning Glass Works, N. Y. EDWIN P. ARTHUR, Beckman Instruments, Inc., Fullerton, Calif. G. D. BACHMAN, Armstrong Cork Co., Millville, N. J. R. E. BRICK, Continental Can Co., Chicago, Ill. EDGAR H. HAMILTON, National Bureau of Standards, Washington, D. C. W. L. HARTOP, JR., Abbott Lab., North Chicago, Ill. A. L. HINSON, Kimble Glass Co., Vineland, N. J. JOSEPH P. MAJESKE, T. C. Wheaton Co., Millville, N. J. MARTIN E. NORDBERG, Corning Glass Works, Corning, N. Y. J. P. POOLE, Brockway Glass Co., Brockway, Pa. ROY E. SHINN, Hazel-Atlas Glass Div., Continental Can Co., Plainfield, Ill. R. L. TIEDE, Owens-Corning Fiberglas Corp., Newark, O. CHARLES W. TREPTOW, Baxter Lab., Inc., Morton Grove, Ill. B. E. WIENS, Owens-Illinois Glass Co., Toledo, O.

Tubulated stems, shown in production here, are only as good as the seal between the glass and the metal. Chromizing the wires has simplified sealing and reduced the number of leakers.

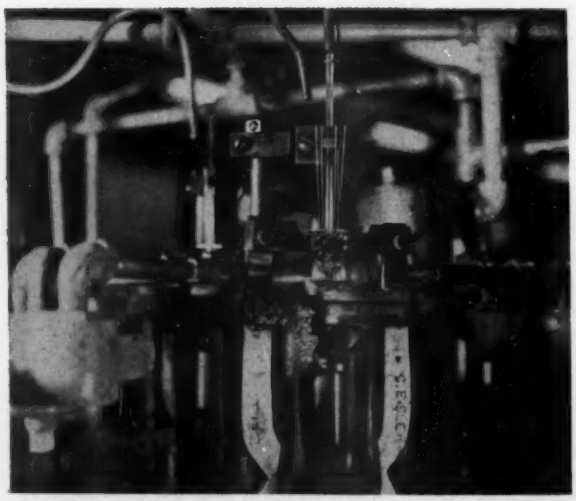


Prebeaded lead wires are shown being inserted into the jig, prior to placement of the glass sleeve. Although relatively new, the use of chromized seals in electron tube production holds real promise.

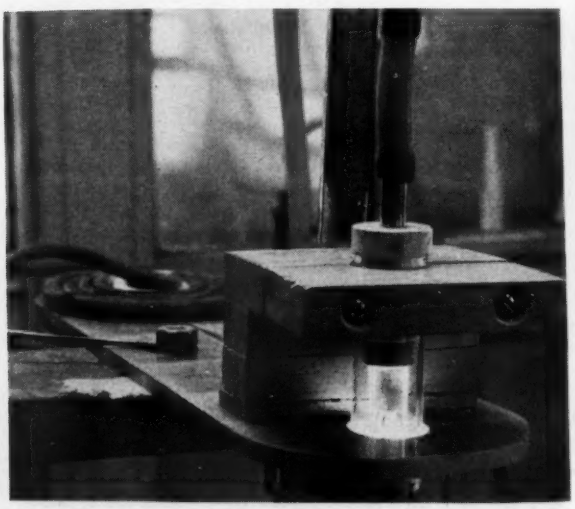
Chromizing Simplifies Glass-to-Metal Seals

Generally, the best metal-to-glass seals are obtained by oxidizing the metal and then diffusing this oxide into the glass for a vacuum-tight seal. The metal and the glass must be closely matched in thermal coefficients of expansion and the oxide must adhere tightly to the metal base, completely wetting the matching glass. In achieving these two requirements, manufacturers of glass-to-metal seals must overcome the problems of over-oxidation and expansion. (See *American Scientific Glassblowers Society*, "Metal Diffusion Techniques and Glass Sealing Problems in the Electron Tube Industry" and "A Solder Glass Sealed Vacuum Envelope to Operate at 500°C Ambient Temperature," page 502.)

These difficulties can be avoided by chromizing the metal



Shown here is the flat press operation. Chromizing of wires has improved the seal between glass and metal, and permits manufacturers of glass-to-metal seals to use hard glasses successfully.



An induction generator heats metal ferrule sufficiently to melt adjacent glass, forming a tight seal between the two. The use of chromized molybdenum eliminates thermal cracking.

Uni rm and careful heating, as well as operator skill and experience, are ssential for proper seal. Chromized seals are replacing many of the onventional types in electronic devices.

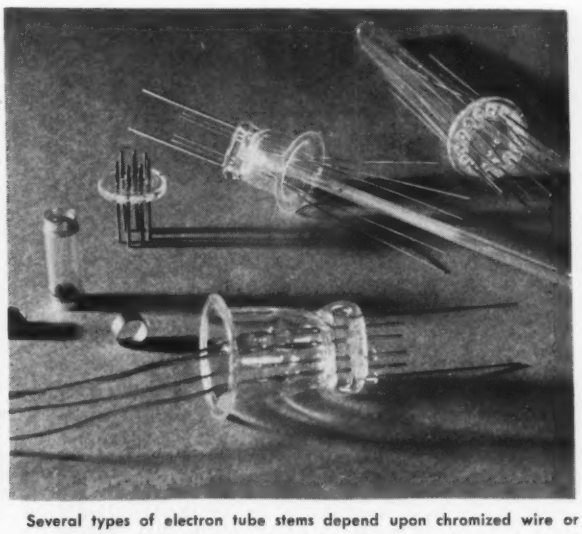
Each tubulated stem coming off this semiautomatic machine is carefully checked for bond, air bubbles, glass configuration, and straightness of pins.

wi or part. A process called Chromallizing, developed by the Chromalloy Corp., West Nyack, N. Y., diffuses chromium an other elements into the substrate, which can be carbon or lloy steel, molybdenum, tungsten, special alloys such as Kovar and Fernico, and even nonmetals such as quartz and graphite. Of these, molybdenum is one of the most suitable metals for electron tube components. However, during sealing in air, several oxides of molybdenum are formed, none of which protects the base. Molybdenum oxide formed in the region of 800°C is a liquid and boils off, leaving the metal exposed to continuous corrosive oxidation.

The chromizing of molybdenum eliminates this problem, and the finished material will withstand temperatures of well over 1000°C for long periods without harm. With chromized metals, seals may be made in air by conventional glass-blowing methods. This makes possible the elimination of one or more production steps, as well as the special controls found necessary to prevent over-oxidation of unprotected molybdenum. Where carbon molds once used in nitrogen-flushed bell jar during fusing of button stems were frequently destroyed by contaminants in the gas, expensive replacements are no longer required. Prebeading molybdenum wire in a protective atmosphere is not necessary; standard fabricated parts can now be used.

This article is based on material provided by S. J. Koch, president, Electron Technology, Inc., Kearney, N. J.

Many cathode ray tubes contain at least one button seal, some as many as four, such as one of the tubes shown here. Production is now simplified because chromized buttons may be heated in air.



Several types of electron tube stems depend upon chromized wire or ferrules for sound glass-to-metal seals. This process saves time and achieves seals that will hold up at high temperatures.

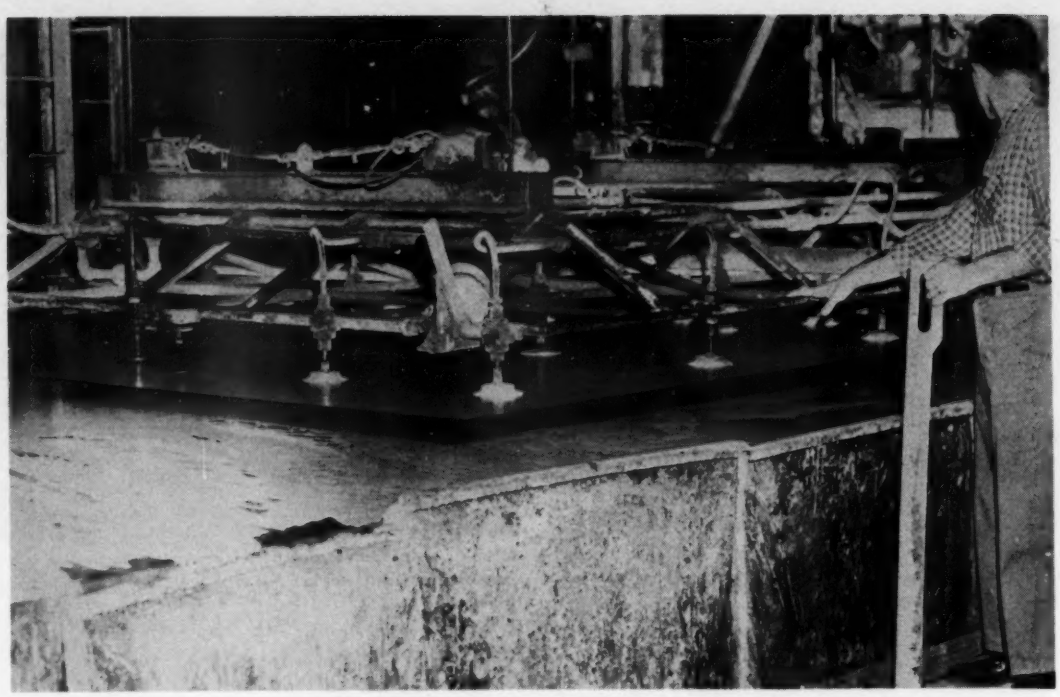


Fig.1. Plate of glass is placed on slurried table by setting crane that picks it up and holds it with suction cups.

Bulk Handling of Gypsum At Ford Glass Plant

One of the growing number of dry, granular materials to be successfully conveyed in bulk by pneumatic handling equipment is calcined gypsum. At Ford Motor Co.'s glass division plant in Nashville, Tenn., a pneumatic system is currently handling 30 tons of gypsum a day.

With 1,160,000 sq. ft. of floor space, and 388,000 more now being added, Ford Motor Co.'s Nashville glass plant is presently the largest integrated (from raw material to finished product) automotive glass plant in the world. It uses as much as 30 tons of gypsum a day, which would ordinarily mean up to 600 bags a day. But Nashville doesn't convey gypsum in bags. They handle it in bulk, from railway car to the grinding and polishing line.

This line, in the shape of a race track, uses standard equipment to grind and polish both sides of the plate glass in two separate operations, one for each side. The line itself is a series of steel tables joined together. At a point where the oval ends and the straightaway begins, there is a stucco mixing station. Next to that is located a pair of day-use bins which hold enough gypsum—up to 18 tons—for a full, 3-shift day's work. The gypsum is conveyed pneumatically to these day-use bins from the large storage bins.

Gypsum and water are mixed at the gypsum application station, and this slurry is spread on each table. Immediately a plate of glass is placed on the slurried table by a setting crane that moves back and forth over the beginning of the line, picking up and holding plates of glass with suction cups (Fig. 1). When the slurry has set (Fig. 2), the line of plates is moved under the first grinders, then continues to pass under the entire series of grinders and polishers. Finally, the gypsum bond is broken and the glass is separated from the table by air pressure.

Another setting crane lifts up the plate and places it on a roller conveyor which moves the glass to a roll-

over unit. Resembling a water wheel, this unit picks up a plate with suction cups, rolls it over 180°, and places it on the other side of the line. The entire operation is then repeated for the other side of the plate glass, which, after having been ground and polished on both sides, has traveled a total of 3800 ft.

Bulk Handling

Gypsum is handled in bulk at Nashville in two operations: *(1)* conveying it from railroad cars to the storage bins, and *(2)* reclaiming it from those bins and delivering it to the day-use bins. Both systems were manufactured and installed by Fuller Co., Catasauqua, Pa.

The first system is set to handle boxcars (10 to 11 tons per hour), hopper-bottom cars (13 to 14 tons per hour), and General American "Airslide" cars.

1. A nozzle is attached to a coupling on a car (Fig. 3).
2. A positive pressure rotary exhauster, driven by a 50-hp, 1200-rpm motor, conveys the gypsum pneumatically from that car through a 5-in. line, up to a filter on the roof, then down to the five storage bins (Fig. 4).
3. The filter is 5 ft. in diameter, and has four compartments. One compartment is automatically cut out of service every 2 minutes, and shaker motors agitate the filter bags in that compartment to clean them. Also, air is reversed through the cloth to augment the cleaning action. The action of the filter is automatic and no compressed air is needed.
4. A rotary airlock and a 53-ft.-long screw conveyor feed gypsum at a rate of 14 tons per hour from this roof filter down to the storage bins, each one of which holds up to 65 tons.

A second pneumatic conveying system delivers gypsum from the storage bins to the day-use bins, when needed, at a capacity of 10 tons per hour.

1. A pump, also driven by a 50-hp, 1200-rpm motor, employs an impeller screw operating against a pressure gate to deliver a uniform rate of gypsum flow from the storage bins to the compression chamber.

2. Air for the compression chamber is supplied by a single-stage rotary air compressor, driven by a 75-hp, 690-rpm motor (Fig. 5). It has an actual part-time free air delivery of 598 cfm at 32-lb. pressure.

3. The gypsum is discharged from the chamber through a 5-in. line to each pair of day-use bins (Fig. 6). One pair is 661 ft. away; the other, 972 ft. away.

One operator can direct all movement of gypsum by means of a control panel which also serves as an indi-

Fig. 3. Pneumatic conveying system unloads gypsum from the hopper-bottom car at a rate of 13 to 14 tons per hour.

Fig. 2. When slurry has set, the line of plate glass is moved along a series of grinders and polishers in the shape of a race track.

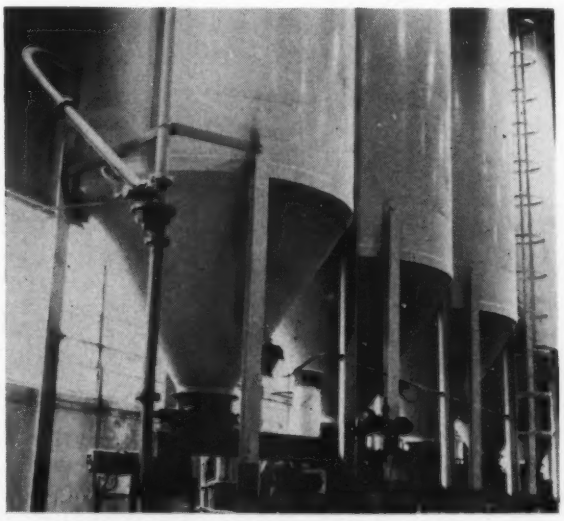


Fig. 4. Each storage bin holds 65 tons of gypsum. Under bins is screw conveyor which feeds gypsum to pump for day-use distribution.

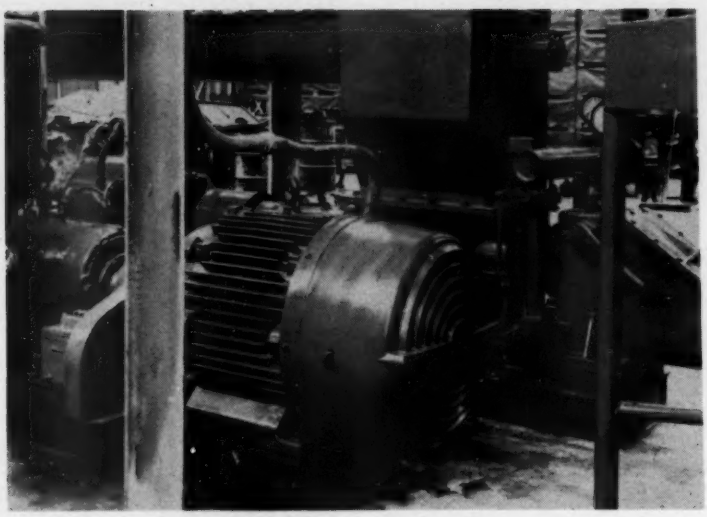


Fig. 5. Pump and compressor deliver gypsum to the day-use bins. Actual free air delivery is 598 cfm at 320 lb. pressure.

cating panel (Fig. 7). From this panel, located next to the storage bins, he can dispatch gypsum from *(1)* a car to any storage bin, or *(2)* any storage bin to any day-use bin. Level indicators in each bin prevent overflow.

Benefits of Bulk Handling

A part-time operator is the entire labor force required for handling gypsum at Nashville. (This man also works on the sand distribution system.) Since all in-plant conveying and car unloading are done during the day shift, no operator is needed on the other shifts.

Considerable savings are realized through the elimination of bags—up to $1.25 a ton. (Bags cost 6 to 7 cents each.) Then, too, by shipping gypsum in bulk, weight and space are reduced.

With bulk handling, there is no danger of accidents involving falling bags, or injuries sustained in lifting bags. Since there are no bags to break, no gypsum is spilled and no cleaning up is needed. In addition, in-plant traffic connected with gypsum handling is eliminated.

Although calcined gypsum is hygroscopic, in 3 years of its handling in bulk at Nashville, there have been no problems with hydration, even during the rainy season.

Furthermore, maintenance people have found that very little work is needed on the pneumatic conveying systems; they are practically trouble-free.

Perhaps the most important aspect of bulk handling of gypsum is that of *positive control.* Gypsum can be sent *where* it is needed *when* it is needed—*just by pushing a button.*

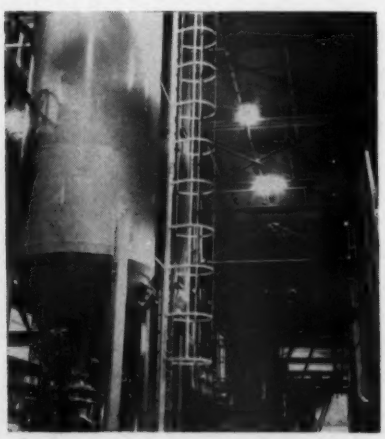


Fig. 6. One day-use bin holds up to 18 tons of gypsum. This pair is 661 ft. from the storage bins, and the other pair is 972 ft. away.

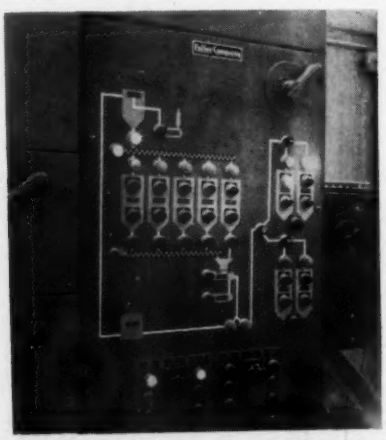


Fig. 7. Control panel operates to direct the flow of gypsum from hopper car to storage bins, and from storage bins to day-use bins.

Bibliography on Glass Structure

PART XIV, CONCLUSION

359 A. E. R. Westman and P. A. Gastaganis

"Constitution of Sodium, Potassium and Lithium Phosphate Glasses," J. Am. Ceram. Soc., 40, 293-9 (1957).

The chain-length distributions in solutions of sodium phosphate glasses were reinvestigated using improved paper chromatographic techniques. The range of compositions was extended to glasses of higher Na/P ratios by using a throughflame technique for their preparation. The distributions obtained confirmed the earlier work with the exception that cyclic phosphates were found in solutions of glasses having or approaching the metaphosphate composition despite prolonged heating of the glasses in the molten condition. The earlier observation was that prolonged heating eliminated the cyclic phosphates. As before, no orthophosphate was found, as predicted by Van Wazer, and neither the Poisson nor the "random reorganization" distributions fitted the data for both high- and low-average chain lengths. Although some sort of rearrangement is occurring in the melt, it may not be a completely random process; a rapid change of chemical properties with chain length of the short polymers may have to be taken into account. This was confirmed by similar studies of potassium and lithium phosphate glasses, whose distributions were found to be different enough to demonstrate a cation effect. Consequently, more than stoichiometry is involved.

360. Woldemar A. Weyl

"The Constitution of Glass," Glastech. Ber., 30, 269-82 (1957); C. A. 52: 676g.

Weyl's approach contrasts with usual model involving ion size, bonding energy, etc. His and Fajans ideas are based on the deformability of ions. Stresses need to study glass from a thermodynamic point of view. Suggests that since mixing entropy is related to degree of order much can be learned about structure from its determination.

361. A. Winter

"Glass Formation," J. Am. Ceram. Soc., 40, 54-8 (1957).

Only elements S, Se and Te of Group VI in the periodic table are known to form monatomic glasses. They retain their glass-forming properties even when mixed together. These elements also form binary glass with elements from Group III, IV and V; 20 such glasses have been prepared. Some glasses are also known between Group VII, and an element in Groups II, III and IV or a transition element.

362. George Zarzyeki

"The Bond Angle Si-O-Si in Vitreous Silica and Ge-O-Ge in Vitreous of Liquid Germanium Oxide," Verres et Refractoires, 11 (3-8) (1957).

Radial atomic distribution curves were calculated for SiO_2 at 20°C and 1600°C and for GeO_2 at 20°C and 1200°C. Speculation about the relationship of structures to quartz and cristobalite is made.

363. Ernest M. Levin and Stanley Block

"Structural Interpretation of Immiscibility in Oxide Systems; III. Effect of Alkalis and Alumina in Ternary Systems," J. Am. Ceram. Soc., 41 (2) 49-54 (1958).

The structural interpretation of immiscibility expounded in parts I and II is extended to include the effect of homogenizers, i.e., alkalis and alumina. Consistent with previous deductions, coordination configurations are postulated to illustrate the dominant role of the homogenizer cation in coordinating incompatible structural units of the melt. Two semi-independent methods are used to arrive at a quantitative estimation of the amount of homogenizer required for complete miscibility in ternary silicate and borate systems. Both methods yield values of the proper order of magnitude when compared with the limited amount (both in extent and accuracy) of available observed data. 4 figures, 6 references.

For Part II see ibid, *40* (4) 113-18 (1957).

364. Walter Huckel

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367. G. O. Jones

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368. "The Vitreous State," a symposium, 154 pp. (1955). The Glass Delegacy of the University of Sheffield. (Book.)

369. O. L. Anderson and D. A. Stuart

"Statistical Theories Applied to the Glassy State," Ind. Eng. Chem., 46 (1) 154-60 (1954).

370. Scott Anderson, Robert L. Bohon, and Dudley D. Kimpton

"Infrared Spectra and Atomic Arrangements in Fused Boron Oxide and Soda Borate Glasses," J. Am. Ceram. Soc., 38 (10) 370-77 (1955).

371. S. Bateson

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372. P. Beyersdorfer

"Ideal Glass and Real Glass," Silikat Tech., 1952, 3 (12) 549-552.

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"Dependence of the Properties of the Glass on Its Thermal History," J. Soc. Glass Tech., 14, 280-4 (1930).

374. Sven V. Berger

"Crystal Structure of Boron Oxide," Chem. Scand., 7 (4) 611-22 (1953).

375. M. A. Bezborodov

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Reprints of *Bibliography on Glass Structure*, compiled by the ACS Basic Science Division, are now being prepared in limited quantity only. An Index, not to be published in THE GLASS INDUSTRY, will be incorporated into the complete *Bibliography*. 44 pages. $6.50 plus postage per single copy.* Discounts on orders of 10 or more. No orders filled after October 15, 1961.

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Reader Service Card: Circle No. 22

The Permalife Glass Fiber Div., Standard Electric Co., Inc., of San Antonio, Tex., is currently spinning in excess of 4 billion ft. of fiber glass daily, from which they manufacture battery separators. These separators are being widely used by battery makers in the United States as well as in 3[illegible] foreign countries.

FIBER GLASS BATTERY SEPARATORS

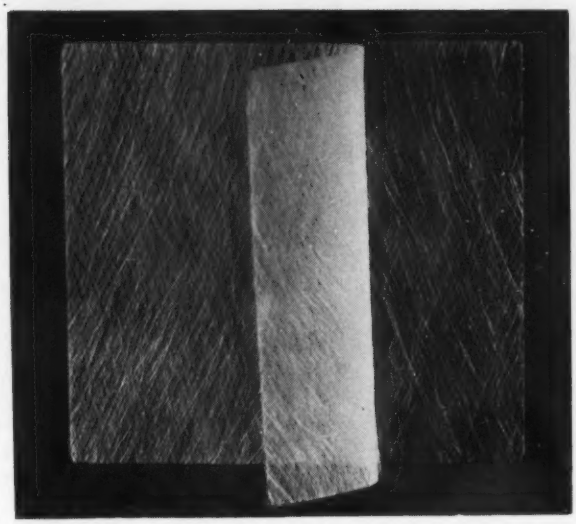


Fig. 1. Fiber glass side of a battery separator showing a portion of the glass fiber mat imbedded 0.005 in. into latex and earth backing.

During World War II, research was begun on an all-glass battery separator developed as a substitute for the microporous rubber separator which was then the best available, but in short supply. It was soon discovered that the addition of a filter backing to the glass fiber mat created a new concept in insulation for storage battery plates.

This improved separator consisted of *(1)* a heavy spun glass mat to fit against the positive plate, and *(2)* a filter pad made of latex and diatomaceous silica to fit against the negative plate (Fig. 1). It was found to be superior in nearly every respect to the older rubber separator for which it was originally pinch-hitting. Today, an average of 50 of these separators are used in one lead-acid storage battery.

Processing

The manufacture of Permalife separators begins with the drawing of continuous strand glass fibers from gas-fired traversing furnaces (Fig. 2). Here, the basic mate-

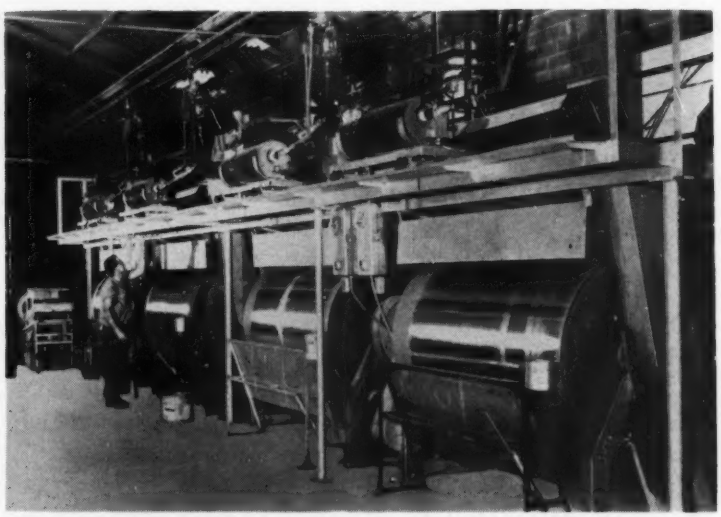


Fig. 2. One bank of spinning drums. Fibers are drawn from traversing furnaces overhead and wrapped on rotating drums.

Fig. 3. Glass is expanded by hand, fed into calendar rolls for more thorough expansion, passed under binder, then into oven for drying.

rial consists of uniform glass cullet with a melting point of about 1400°F. The glass fibers are then spun into a condensed mat of a weight predetermined to give the mil thickness desired in the finished expanded mat. This in itself is a precision operation because the tolerance of a finished separator must be ±0.004 in.

When the required amount of fibers has been spun, the condensed mat is cut and removed from the drum, then cut into two half-mats. Each half-mat is expanded mechanically in a set of synchronized calendar rolls (Fig. 3), then passed under a "water fall" where it is saturated with a liquid binder of polystyrene and latex. This expanded mat next passes over a vacuum bar where excess binder is drawn out, and then on through a processing oven which sets the binder and dries the finished basic mat. After inspection, the basic mat is trimmed and wound into jumbo rolls (Fig. 4).

A number of these rolls are selected for each individual order and sent to the coating department. Here the basic mat is fed through an electronically operated coating machine which applies a filter backing of latex and diatomaceous earth (Fig. 5). This backing is applied in slurry form at a uniform thickness controlled to 0.001 in. The two layers, consisting of glass fiber mat and the slurry coating, are carried on a conveyor through a tunnel-type oven. Here the latex is cured and the two layers are bonded into one. Finished battery separator material emerges from the curing oven and across a quality control candling table for 100 per cent inspection (Fig. 6). From there it moves on through an automatic slitter-chopper where it is cut into individual separators.

These separators literally pour from the slitter-chopper onto another conveyor for inspection and, if found defective, rejection. Satisfactory separators are then taken off the inspection conveyor belt, checked for mil thickness, and packed in cartons for shipment to customers (Fig. 7). Mil thickness must be carefully controlled to meet the close tolerance allowed in cell group burning machines. Because every battery manufacturer specifies his own battery plate dimensions (height, width, and thickness), each order is custom made. To inventory all sizes of separators would be impractical.

Application

Approximately 1½ billion separators will be consumed this year by battery manufacturers throughout the world. Of these, an increasing number are fiber glass. Paper, wood, cellulose fiber, and microporous rubber separators are also available to the battery industry, but the last, used in conjunction with the glass fiber retainer mats, achieves maximum effectiveness.

The life of lead-acid storage batteries is largely influenced by the separators. These, in turn, are subject to the

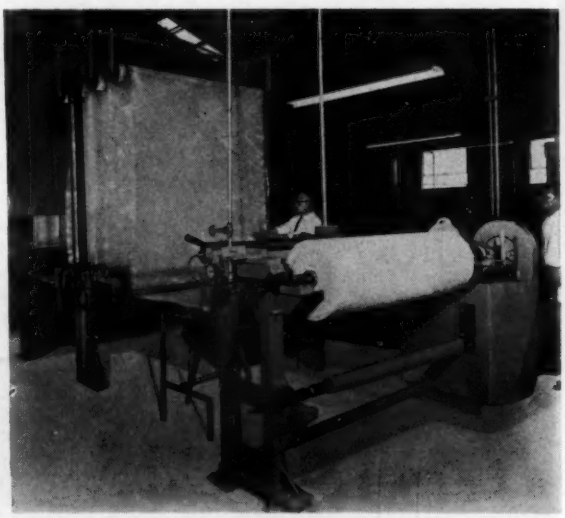


Fig. 4. Cured mat comes from binder oven, is inspected, trimmed, and rolled. Quality, thickness, and ignition loss binder content are checked.

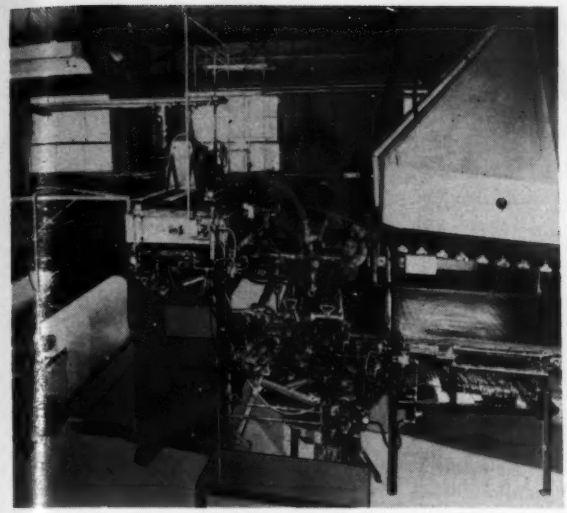


Fig 5. Basic glass mat is fed through slurry coating machine where a filter backing of liquid latex and diatomaceous earth is applied.

Fig. 6. Cured material emerges from oven and illuminated imperfections are marked on candling table. Material is then slit and chopped.

effects of sulfuric acid, heat, vibration, and oxidation attack. One of the more common battery failures is caused by particles of oxide falling from the positive plate as a result of vibration. Not only does the positive plate lose capacity as these particles fall away, but after a sufficient quantity of positive oxide material builds up in the bottom of the battery case, it will touch the bottoms of the negative plates and short across. Other separators must be ribbed to permit ample circulation of electrolyte around the plate, but the heavy glass fiber mat separator presents a flat surface against the positive plate to prevent shedding, while the open areas between the glass fibers allow adequate electrolyte circulation.

Another problem in lead-acid storage batteries is antimony contamination. It is necessary to put a certain percentage of antimony into the lead grids of battery plates to give them strength. During battery cycling, the antimony is electrochemically drawn from the positive grids and attached to the negative plates. Once a negative plate has been contaminated with antimony, it actually becomes a battery within itself, and therefore, is affected by self-discharge. When this occurs, the battery loses its ability to retain a charge. The diatomaceous earth included in the slurry with which Permalife fiber glass mats are coated acts to block this antimony migration. Furthermore, these fiber glass separators are the only separators not oxidized after continuous submersion in acid while being subjected to battery cycling.

Because fiber glass is inert and imune to the destructive elements at work in batteries, its application in battery separators has helped to make possible these considerable advances in the field.

Fig. 7. After marked defects are removed from inspection conveyor belt, separators are checked and packed for shipment.

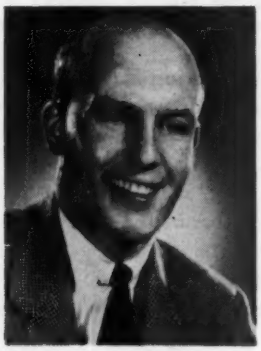
NEWS

William R. Browne

Given sales responsibility for fiber glass textile products in the New York area, and Thomas H. Kiernan assigned to the Chicago territory, for Johns-Manville Sales Corp. Edward J. Bodette has been appointed staff manager for the firm's electrical and industrial yarns division.

The 60,000-sq. ft. addition to the Johns-Manville Fiber Glass plant in Waterville, O., scheduled for completion last month, will expand manufacturing, warehousing, and shipping space by 30 per cent. Fiber glass production capacity is expected to be increased by 40 per cent.

The Richmond plant is currently engaged in $600,000 expansion and development program that will add experimental equipment to develop a new fiber glass insulation for applications in the appliance industry.



William R. Browne

Norman F. Heydinger

Recently resigned from his position as manager of marketing research for the Fiber Glass Div., Pittsburgh Plate Glass Co., has been appointed director of the newly-established industrial division of Rogers National Research. Prior to joining PPG in 1959, he was manager of marketing research and assistant to the vice-president, sales, of Libbey-Owens-Ford Glass Fibers Co.

John L. Stief

Of Coast Mfg. & Supply Co., Livermore, Calif., has been elected chairman of the Prepreg Div., Society of the Plastics Industry. He succeeds Grant Brown of Cordo Chemical Co., first chairman and organizer of the division. H. J. Reid of Standard Insulation Co., East Rutherford, N. J., will serve with Stief as vice-chairman.

Homer L. Andrews

Appointed manager of market research, Molded Fiber Glass Co. This newly-formed department will be available to customers as well as to the management of the five MFG companies.

Duane C. Searl has been named manager of quality control for the Molded Fiber Glass Body Co. At the same time, MFG has announced that its testing and research facilities at Ashtabula, O., are available without charge to assist customers in materials selection, product design, and quality control.

Thomas H. Kiernan

The firm has also launched a $1.5 million expansion program which will include a new molding plant and office building at its Ashtabula headquarters.

John K. Whittaker

Named president of Modiglass Fibers Inc., a subsidiary of Reichbold Chemicals, Inc. He is a member of the Society of the Plastic Industry, Inc., and, prior to his new appointment, served Modiglass as executive vice-president.

Fiber Glass Plant in Holland

N. V. Silenka AKU-Pittsburgh will begin construction October 1 on a textile yarn fiber glass plant in Hoogezand, Holland. Completion date is scheduled for late in 1962.

The new firm is owned jointly by Pittsburgh Plate Glass International and Alegemene Kunstzijde Unie S. V. of Arnhem, Holland. The facility will be equipped initially to produce yarn roving, chopped strand, and mat. These products will be marketed in 18 European countries.

Taylor Fibre Co.

Of Norristown, Pa., has entered the field of filament-wound fiber glass reinforced plastic parts. The firm is now producing these parts in almost every size required for current military and industrial applications.

Edward J. Bodette

Gustin-Bacon Mfg. Co.

Reported net sales for the 9 months ended June 30 as 7.7 per cent higher than sales for the corresponding period a year ago. Net income was virtually unchanged. Net sales were $24,816,980. up from $23,044,918 last year.

B. F. Goodrich Aviation Products

Has established complete engineering and production facilities in Akron, O., for the manufacture of filament-wound fiber glass structures required in the aircraft, missile, and space flight fields.

Fall Symposia

Owens-Corning Fiberglas Corp. will conduct a series of seminars this fall covering the correct sewing and installation procedures for fiber glass fabrics and the commercial laundering of fiber glass curtains and draperies. The company is also sponsoring the organization of a professional workshop by the New York chapter of the American Institute of Interior Designers. These courses are being designed to present the latest technical advances in the home furnishings industry.

On the scent of success

. . . for a new perfume glass container . . . and production problems of cause and effect must be solved to assure that success. So, when Earl Flatter, Overmyer vice-president, visits a glass plant, it is often to help meet the challenge of the "how" and "why" of production. A new glass container means major investment . . . in labels, closures, cartons, advertising. So before there can be even mould production, check and recheck must be made. Can it be made on the machines of that plant? . . . what type of mould equipment? . . . what kind of iron? . . . will it be efficient at high speed? To these questions Earl Flatter brings related past experience that is industry-wide. He and other Overmyer executives and technicians have had a part in the progress of glass . . . for a long time!

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FIBER GLASS SPACE FILTER has increased in moisture resistance with the addition of a permanent water repellent to the basic glass microfiber medium in the manufacturing process. The resulting product acts as a water coalescer and separator. Originally designed to provide protection against airborne radioactive particulate, this filter element is now adaptable to a wide variety of applications in the pharmaceutical, photographic, optical, and other processing industries. *Mine Safety Appliance Co.*

Reader Service Card: Circle No. 50

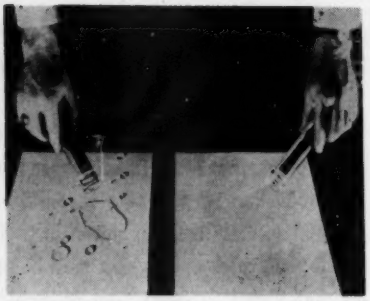
MOBILE HOMES are reported to be a fast-growing market for fiber glass. Fiber glass insulation is now being used in practically all dwellings of this type, and an increasing number of the body panels are being fabricated of fiber glass reinforced plastic. *Owens-Corning Fiberglas Corp.*

Reader Service Card: Circle No. 51

NEW INSULATION FOR THE TRANSPORTATION INDUSTRY uses long chopped textile fibers. Marketed as "Textrafine", it is being produced in densities ranging from ¾ lb. to 3 lb. per cubic foot, in thicknesses from ½ in. to 6 in. The product, claimed to be particularly applicable where great dimensional stability is required, has been developed for railroad, truck-trailer, and marine consumption. *Fiber Glass Div., Pittsburgh Plate Glass Co.*

Reader Service Card: Circle No. 52

DOMESTIC FREEZERS AND REFRIGERATORS can be built with considerably thinner walls using available fiber glass insulating materials.



Water globules shed from new medium (l.) while older medium (r.) absorbs water.

A wall insulated with air-filled fiber glass can be made as thin as 1.3 in., and achieve satisfactory thermal performance with substantial savings. *Owens-Corning Fiberglas Corp.*

Reader Service Card: Circle No. 53

WET SLURRY PROCESS of reinforcing plastic moldings with fiber glass has been found to be advantageous for the manufacture of high-strength, low-weight components such as housing and casings. The designer has wider latitude in specifying sharp corners, and variable cross sectional thicknesses can be readily obtained. Water impaction of the fiber glass reinforcement produces radii as small as 1/32 in. with no loss of strength or resin richness. *The Cincinnati Milling Machine Co.*

Business machine cover molded of fiber glass at one-fifth the usual tooling cost.

Reader Service Card: Circle No. 54

DAYLIGHTING PANELS of fiber glass triple-reinforced laminate have been introduced for roof and sidewall lighting, partitions, replacements of existing sash and glazing, and other home, commercial, and industrial applications. They are reported to be the first to use 100 per cent acrylic resin as a wetting agent. The panel is also said to demonstrate outstanding resistance to weathering of all kinds and to provide superior light diffusion. *Owens-Corning Fiberglas Corp.*

Reader Service Card: Circle No. 55

THERMAL AND ACOUSTICAL INSULATION is now available for marine applications. The material is fabricated entirely from fine glass fibers bonded with a phenolic resin, and it has an average density of 2¾ lb. cu ft. Called "NAV-hul Board," the product meets Navy specifications and is being used for hulls, bulkheads, and overheads. *Fibrous Glass Products, Inc.*

Reader Service Card: Circle No. 56

CATALOGS RECEIVED

Fiber glass automotive materials (14 pages). New brochure gives applications and case histories of fiber glass in the building of car and truck bodies. Outlines cost savings and design advantages. Illustrated with some 50 drawings and photographs. *Owens-Corning Fiberglas Corp.*

Reader Service Card: Circle No. 57

Fiber glass boats. Information kit contain photos and copy on a variety of 1961 craft made by leading boat builders. Covers outboard runabouts, inboards, cruisers, sailboats, utility units, a new inboard-outdrive, and a water jet unit. Background material on fiber glass boat building techniques is included. *Johns-Manville Corp.*

Reader Service Card: Circle No. 58

Laundering fiber glass drapery fabrics (8 pages). A report covering proceedures recommended for professional laundering services and building maintenance personnel. The result of a year's study, this release points out that many of the machine laundering methods for cleaning heavier commercial draperies are both harmful and uneconomical. Includes step-by-step outline of advised washing procedures, a listing of practical washing tanks, and a diagram of equipment needed. *Pittsburgh Plate Glass.*

Reader Service Card: Circle No. 59

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NEWS
IN THE GLASS INDUSTRY

Raymond S. Fries

Minneapolis-Honeywell Regulator Co.

RAYMOND S. FRIES named manager of manufacturing and engineering of the Brown Instruments Div. He was formerly manager of new products and their manufacture in Minneapolis.

New NBS Laboratories

Secretary of Commerce Luther H. Hodges broke ground earlier this summer for the $140 million National Bureau of Standard research facility at Gaithersburg, Md. The ceremony marked the initial construction phase for the 20-building project which is scheduled for completion sometime between 1963 and 1965.

Francis W. Theis

Pittsburgh Plate Glass Co.

FRANCIS W. THEIS elected vice-president, international, with headquarters in the Pittsburgh general offices . . . BJORN HOLMSTROM will succeed Theis as president of Pittsburgh Plate Glass International, S. A., in Geneva, Switzerland . . . JOHN H. HENSHAW, vice-president, sales, will be responsible for the direction of the international firm's San Juan, Puerto Rico, office . . . CLIFFORD H. SWENSEN appointed technical director of International S. A.'s newly incorporated subsidiary, Pennitalia, S.p.A. which is building a sheet glass plant in Italy. JOHN A. DEFRANCES has been named project leader and assistant to Swensen . . . In the glass division, JOHN H. BUSCH has been made general manager. EDWARD J. SLACK will manage the Ford City Works, and J. H. ELLIOT, the Kokomo, Ind., plant.

James H. Taylor

Emhart Mfg. Co.

JAMES H. TAYLOR assigned to the new post of products and market planning manager. He was previously assistant to the vice-president of Standard Packaging Corp., and also served with Continental Can Co. as general manager of manufacturing.

Knox Glass, Inc.

LAMBERT M. KASPERS elected vice-president, operations . . . EUGENE M. TYNDALL appointed general sales manager for southern operations.

E. C. Smith Mfg. Co.

The Conshohocken, Pa., manufacturers of thermocouple temperature measuring elements and accessories have changed the firm name to Smith Thermotronics, Inc. . . . ROBERT L. DYER has been named new general manager for the company.

Owens-Illinois Glass Co.

GEORGE W. ALEXANDER promoted to the newly-created position of sales administrative manager of the Libbey Glass Div. . . . THOMAS A. JENKINS becomes sales manager of the glass container division's Cleveland branch . . . R. R. ROBINSON made a special sales representative in the Cleveland area . . . In the container division's New York sales office, J. A. CROWLEY has been named regional manager for beverages, THOMAS R. FRANCIS regional manager for drugs and chemicals, and R. J REYNOLDS regional manager for the food industries.

FINANCIAL DATA

6 Months Ended June 30

American Potash & Chemical Corp.

	1960	1961
Net Earnings	$ 2,621,306	$ 2,140,601
Net Sales ..	$ 26,423,822	$ 22,781,147

General Refractories

	1960	1961
Net Earnings	$ 2,827,830	$ 1,739,598
Net Sales ..	$ 37,473,206	$ 25,783,052

Knox Glass, Inc.

	1960	1961
Net Earnings	$ 336,573	
Net Loss ..		$ 186,190
Net Sales ..	$ 19,524,998	$ 21,110,135

Owens-Illinois Glass Co.

	1960	1961
Net Earnings	$ 17,966,666	$ 16,540,288
Net Sales ..	$279,200,447	$285,841,646

Pittsburgh Plate Glass Co.

	1960	1961
Net Earnings	$ 25,723,044	$ 13,150,547
Net Sales ..	$323,971,191	$283,840,433

Wyandotte Chemicals Corp.

	1960	1961
Net Earnings	$ 2,024,000	$ 1,717,000
Net Sales ..	$ 46,644,000	$ 46,723,000

9 Months Ended June 30

Brockway Glass Co.

	1960	1961
Net Earnings	$ 2,470,373	$ 1,425,468
Net Sales ..	$ 38,718,435	$ 40,337,485

Potash Expansion

International Minerals & Chemical Corp. has announced plans for a $10 million expansion of its Canadian subsidiary's potash production facilities. This will boost output potential from 420,000 to 1,200,000 tons a year in an effort to meet expected sales demand.

Allied Chemical Corp. Solvay Process Div.

JAMES F. ADAMS, JR., transfered to New York as assistant to the director of sales . . . ALEXANDER H. MACDONELL succeeds Adams as manager of technical services in the Syracuse office . . . JOHN L. ROURKE appointed assistant manager of the Syracuse plant . . . CHARLES R. SHULTZ and HAROLD J. FROTH named assistant purchasing agents for six plants.

Selas Corp. of America

FREDERICK O. HESS, president of the Dresher, Pa., firm, appointed to the Committee on New Frontiers of Technology, the United States Chamber of Commerce . . . CHARLES R. WILT, JR., named assistant chief engineer at Dresher . . . Major Furnace and Combustion Engineers Pty, Ltd., of Melbourne, Australia, has been licensed to build and sell Selas heat processing equipment for the glass and ceramic industries in Australia.

Stauffer Chemical Co.

HENRY MOORE has joined the West End Chemical Co., a division of Stauffer, as glass technologist and glass furnace engineer. In his new position he will be available to the company's soda ash customers as a consultant.

Leeds & Northrup Co.

ALEXANDER H. REYNOLDS elected a vice-president with responsibility for long-range planning . . . STEPHEN LOIDL, JR., becomes treasurer and controller . . . ELWOOD F. ROGGE named director of manufacturing . . . J. FREDERICK SHOCK, manager of the order control division, has assumed the responsibility of local manager at North Wales . . . WILLIAM M. FREELEY becomes manager of the plant engineering and services division . . . DONALD E. MOAT and JOHN F. QUEREAU appointed vice-presidents.

Pemco Corp.

A merger of the firm into The Glidden Co. has been approved by directors of both companies. Under terms of the proposed agreement, Glidden will exchange 200,000 shares of a new 4¼ per cent convertible stock for the 100,000 outstanding shares of Pemco common, with the new Glidden issue convertible at any time into a total of 225,000 shares of Glidden common at an approximate conversion price of $45 a share. A meeting of the stockholders of both firms is to be called soon . . . A new addition to Pemco's research facilities, now under construction, will be devoted to the study of metal and the application of porcelain enamels and ceramic coatings to metal surfaces.

Laboratories To Have New Name

Preston Laboratories, Inc., of Butler, Pa., has been renamed American Glass Research, Inc., as of July 1, 1961. The firm is continuing its operations at the 100-acre site in Butler which it has occupied since its founding in 1936.

O. R. Magoteaux

The Chas. Taylor Sons Co.

ROBERT W. KNAUFT, president of the Cincinnati, O., firm, has been elected president of the Refractories Institute . . . O. R. MAGOTEAUX named to research and develop new processes and products. He has been transferred from National Lead Co., of which Taylor is a subsidiary.

Consumption of Soda Ash Rising

The glass container industry, which accounts for approximately 77 per cent of the nearly 1½ million tons a year of soda ash now being consumed by the glass industry, is expected to effect a considerable increase in this tonnage during the first half of this year. Flat glass manufacturers use about 20 per cent of the total tonnage consumed by the glass industry, with pressed and blown glassware accounting for about 10 per cent.

FMC Corp.

DR. CARL E. BARNES has joined the firm as vice-president, research. He will be primarily responsible for research, development, and patent activities within the chemical divisions. For the past 8 years, Barnes has been vice-president

Dr. Carl E. Barnes

and research executive for Minnesota Mining & Mfg. Co. . . . MUNRO M. CARROLL and ROBERT W. BENNETT have been added to FMC's expanded chemical operations department in New York.

Chrysler Signs Distributors

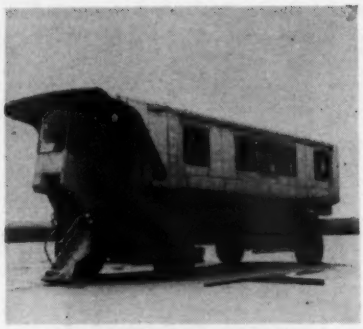
More than 1100 glass installers and 120 warehouses throughout 50 states are included in the network of independent distributors that will market Chrysler Corp.'s glass in the automotive replacement field. The glass, called "Safeguard," is manufactured at the firm's Detroit glass plant, which now supplies over half of Chrysler's glass needs.

J. James Offutt

A. P. Green Fire Brick Co.

J. JAMES OFFUTT elected executive vice-president, succeeding L. J. Miller who retired from that post July 1. Offutt has been a vice-president since January, 1958, and was elected a director of the company this past April.

NEW APPLICATIONS IN GLASS...



Exterior of prototype lounge due for testing.

Lounge will carry a maximum of 90 passengers.

Mobile Lounges Equipped With Safety Glass

Glare-reducing laminated safety glass has been installed in the mobile lounges to be used at Dulles International Airport when it opens next year in Washington, D.C. The giant air-conditioned rooms-on-wheels will shuttle between terminal and aircraft parking areas. The glass specified contains Monsanto Chemical Co.'s "Saflex" plastic interlayer. *Laminated Glass Corp.*

Reader Service Card: Circle No. 60

Glass-to-Metal Strength Tested

A glass-to-metal attachment, developed for high-performance aircraft windshields, was recently used to lift a truck trailer weighing 6½ tons. The design, using 6- by 6- by ⅜-in. polished and tempered Corning 1723 aluminosilicate glass, is controversial because it deliberately transfers tensile loads to the glazing by means of bonded side members. The successful demonstration marked 3 years of work on the design, one of three basic types developed by Narmco and Corning for The U. S. Air Force. *Narmco Research & Development, Telecomputing Corp.*

Reader Service Card: Circle No. 61

Sperical Glass Joint

New spherical joint, with reduced stem and drip tip made of hard borosilicate glass, is now available in eleven sizes. *Scientific Glass Apparatus Co., Inc.*

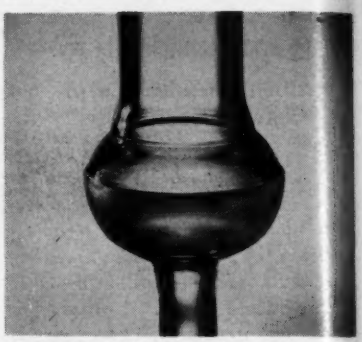
Reader Service Card: Circle No. 62

Glass Tower Masters Wind and Weather

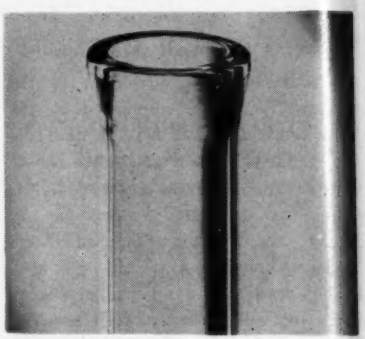
San Francisco's Crown-Zellerbach Building, one of the first major curtain wall structures to use all-glass exterior panels, has passed the critical 2-year mark without detectable leakage. The aluminum-faced tower is almost entirely enclosed in two types of glass, as opposed to conventional curtain wall buildings which have glass panels set in spandrels of metal, concrete, or similar material. The Crown-Zellerbach design increases normal stress on materials that seal and weatherproof the joints, but close inspection has shown that the building, sealed with Thiokol Chemical Corp.'s "Struc*sure*seal," is impervious to wind, water, and dust. *Pittsburgh Plate Glass Co.*

Reader Service Card: Circle No. 63

Winner of 1961 Honor Award, American Institute of Architects. Design: Hertzka & Knowles.



Upper tube and reduced stem measure 6 in.



Glass pipe is made of hard borosilicate glass.

Tooled Glass Pipe Flange

A new, super-smooth tooled glass pipe flange has been developed to meet the needs of milk producers and dairy equipment suppliers. Elimination of tooling marks and heavy ridges allows the pipeline to drain completely clean and dry. *Kimble Glass Co.*

Reader Service Card: Circle No. 64

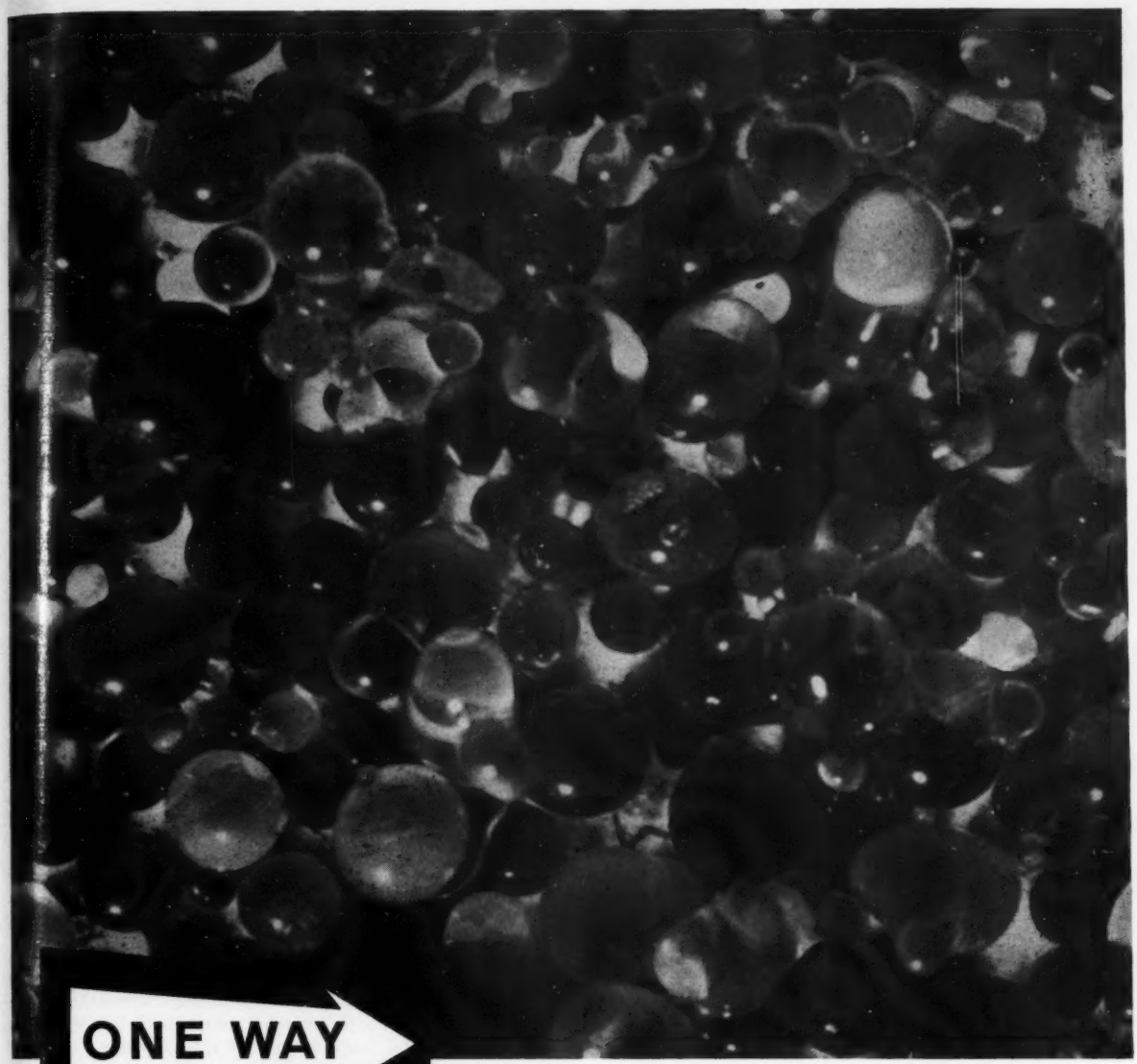
CATALOGS RECEIVED

Capabilities in redrawn glass (4 pages). Gives inside and outside diameter tolerences; charts roundness and concentricity for various diameters of tubing. Complete range of glass from borosilicate through the metal-sealing glasses, including quartz and Vycor, is covered. *T. H. Garner Co.*

Reader Service Card: Circle No. 65

Silicones and their uses (8 pages). Catalog CDS-129C contains photos and data pertaining to various new silicone products, and includes a complete selector guide for silicone rubber. *General Electric Silicone Products Dept.*

Reader Service Card: Circle No. 66



ONE WAY

to give glass greater visibility ...TITANOX®-TG

This photo is a magnification of the tiny glass beads that give modern traffic paints and signs outstanding visibility at night. TITANOX-TG is the specific titanium dioxide for use in glass beads that derive greater reflecting power from higher refractive index.

TITANOX-TG best provides the wide range of valuable effects titanium dioxide imparts to many glass compositions. In addition to increasing the refractive index not only of reflective elements such as glass beads, but also optical glasses, it intensifies and brightens colored glasses ... improves workability ... increases the absorption of ultraviolet in combination with certain oxides ... and produces white or opaque effects—to name a few.

This TiO_2 of exceptional purity is easy to handle and blend with other ingredients in the dry state. For complete details on its applicability to the glass you make or wish to make, we invite you to consult our Technical Service Department. Titanium Pigment Corporation, 111 Broadway; offices and warehouses in principal cities. In Canada: Canadian Titanium Pigments, Ltd., Montreal.

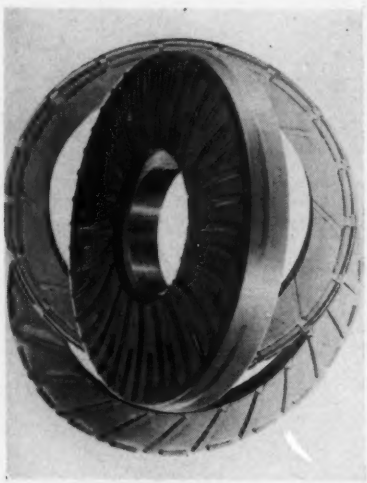
TITANIUM PIGMENT CORPORATION
SUBSIDIARY OF NATIONAL LEAD COMPANY

Reader Service Card: Circle No. 25

NEW EQUIPMENT AND SUPPLIES

Diamond-Impregnated Pellets

Diamonds are rapidly replacing loose-grain methods in finishing operations. This trend has, in turn, spurred the developement of diamond-impregnated pellets and serments for use in optical and flat glass grinding and finishing. It is now practical to impregnate extremely fine-mesh, specially graded diamond powder into bonded surfaces for rough and fine finishing grind glass, quartz, and various other ceramic materials.



Diamond-impregnated segments for rough and finish grinding of flat glass, ceramics, quartz.

Introducing coolant in sufficient quantity and in the right place to form a wetting and lubricating film, or wedge, between the diamond surface and the work piece has frequently proved troublesome. This has been particularly true where diamonds of 500 mesh and finer are used. The exposure of each cutting tooth barely projects above the surface of the bond in which the diamonds are imbedded. Therefore, when solid laps or large areas are moved over a given work surface, it has been difficult to drag through enough coolant to prevent starving of the work surface. When this happens, heat is generated, causing burning and disturbing of the normal fine-surface finish required.

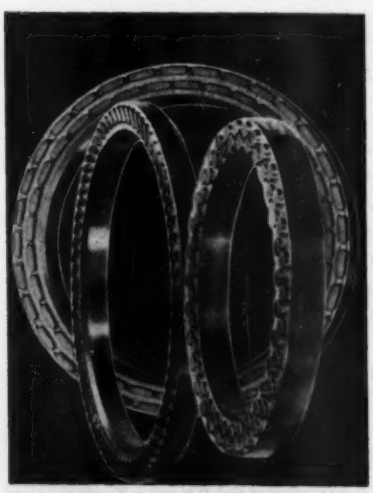
However, when diamond-impregnated pellets or segments of relatively small diameter are properly spaced and anchored to a suitable fixture, there is adequate space for the coolant to be flooded through. In addition, a sufficient amount can be carried under the work surface of each pellet or segment, providing the best wetting and lubricating action. This makes possible the rapid flushing away of ground sludge and impurities that otherwise tend to collect on the diamond surface, seriously impairing the surface preparation for the final polishing stage.

Where various laps, ring tools, or plano-type wheels are used, a single size and grade of pellets or segments can be stocked in quantity for assembly into required shapes, sizes, and arrangements. (If solid laps or rings are used, it is necessary to maintain a special size and shape for each application or job requirement.) Pellets and segments can easily be soldered or fastened with adhesive to steel, bronze, or cast iron backs.

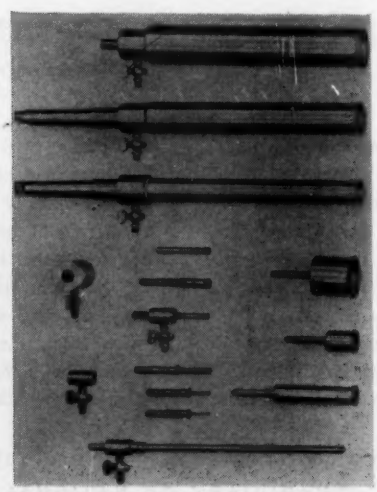
In some applications, the rectangular or oblong segment has proven more practical than the round increment. Such is the case with Blanchard's large diameter ring tools, and also for certain other surface grinding equipment. Even in these instances, however, the use of segments is increasing in diamond roughing and finishing operations. Because of the free cutting action of this type of assembly, segments have proven more efficient and economical for delicate operations where lack of coolant can create grinding and finishing hazards on expensive, critical materials.

Pellets and segments are now available in sizes ranging from $\frac{1}{8}$ in. to 1 in. or more in diameter. Individual material, equipment, stock removal, and finishing requirements must be considered. *Super-Cut Distributors, Inc.*

Reader Service Card: Circle No. 67



Oval, round, and oblong pellets positioned in Blanchard machine rings in various patterns.



Special diamond core drills are being manufactured to users specifications.

Glass Treatment Compound

Called "GTC-59", this new compound is said to cut glass and plastic maintenance costs. It cleans and degreases in one operation and leaves a clear, water-repellent, protective surface. Static fields which attract dust and dirt are cancelled and the surface is kept free from dirt buildup. This compound is also said to have excellent antifogging properties. *Beaver Lab. Inc.*

Reader Service Card: Circle No. 68

Electron Mircroscope

Can heat, chill, or subject a specimen to stress and take pictures of the moment-by-moment changes which result. Several attachments, including a cine-camera, give the instrument versatility. *Fisher Scientific Co.*

Reader Service Card: Circle No. 69

Automatic Carton Elevator

Elevates cartons and discharges them at another floor level or into a raised storage or accumulating area. Cartons are elevated in a vertical stack and held on pivoting shelves. Machine can also be used as a vertical compression unit for cartons as they come out of the case sealer. Occupies a minimum of floor space. *Lathrop Paulson Co.*

Reader Service Card: Circle No. 70

Marking System for Glass

New ink which dries on nonporous surfaces can be used with specially designed hand printing devices that print from a stencil. This permits marking of product identification, code numbers, etc., directly on glass surfaces that have in the past been marked by hand. Information can now be marked at the rate of 40 to 60 prints a minute. Ink dries in a few seconds, enabling its use on the production line. *Weber Marking Systems Inc.*

Reader Service Card: Circle No. 71

Adhesive for Glass

An epoxy adhesive called "Conap 1222" is said to offer exceptional adhesion to glass. It cures in 1 hour at 300°F. and will retain strength and resistance to chemical attack even after 30 days of immersion in water. Combines toughness and superior ductility. *Conap, Inc.*

Reader Service Card: Circle No. 72

Glass Tank Controls

Jet pipe-type furnace pressure controllers incorporate automatic reversal. Hydraulic controller requires minimum maintenance and is designed to operate in the abrasive atmosphere of the glass tank. *GPE Controls, Inc.*

Reader Service Card: Circle No. 73

Throw-Away Diamond Core Bit

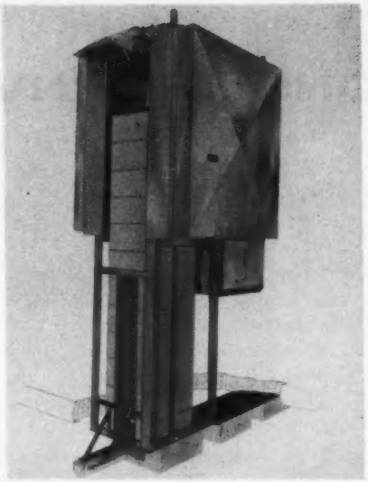
Surface-set bits are manufactured with Grade A diamonds random set in a nonspiral pattern. Although nonresettable, the throw-aways are said to cut faster in critical areas and are low in initial cost. *The Clipper Mfg. Co.*

Reader Service Card: Circle No. 74

Material Handling Tote Tank

Designed for use in factories and for shipping, this unit can be uesd to transport either liquid or bulk materials. Narrow width allows a large number to be carried in typical semivan. *Lull Engineering Co.*

Reader Service Card: Circle No. 75



Carton elevator has a load capacity of 350 lbs. and can handle 20 cartons per minute.

Decorating Machine

Semi-automatic machine for decorating glass containers has a new unit which screens ware up to 4 in. in diameter and 12 in. in height. Features a separate screen adjustment for body and shoulder, an automatic safety device to prevent screen damage due to unchucked ware, and an adjustable timing cycle to synchronize with production line speed. Is said to occupy a minimum of floor space and to enable fast job change-over. *Carl Strutz & Co.*

Reader Service Card: Circle No. 76

Vacuum-Deposited Thin Films

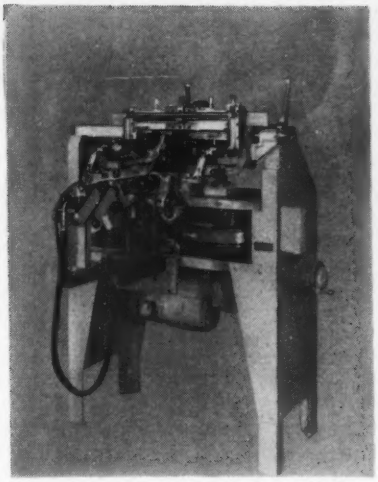
A complete line of standard evaporated coatings is available for optical control and other applications; custom coatings can be engineered to specific requirements. These coatings can be applied to glass, ceramics, metal, plastics, and low vapor pressure plastics. Uniform thickness and quality are assured through the use of spectrophotometric and optical evaluation. *Evaporated Coatings, Inc.*

Reader Service Card: Circle No. 77

Ultrasonic Cleaner

A 5-gal. ultrasonic cleaner offers what is claimed to be the highest cleaning power per unit area yet developed. It operates from a 5-ampere input and develops a generator output of 1200 watts at 40 kc, 4000 watts at 20 kc. The unit includes an electrostrictive transducer, automatic timer, and automatic power control. Generator and transducer are designed so that tuning is unnecessary. *Mettler Electronics Corp.*

Reader Service Card: Circle No. 78



Decorating machine labels 55-60 containers per minute, body and shoulders simultaneously.

Air dryer inlet and outlet are directly opposite for easy insertion into piping system.

Air Dryer for Compressed Air Systems

Has been redesigned for easier installation. Air flow of this 2-stage mechanical/chemical-type machine uses new flow principle for savings in operating costs. *General Welding & Fabricating Co., Inc.*

Reader Service Card: Circle No. 79

CATALOGS RECEIVED

Silicone fluids (20 pages). Describes a broad range of these fluids, some of which are being used as coatings for glass and ceramics. Differentiates between available grades according to viscosity, and classifies them on the basis of physical properties. *General Electric Silicone Products Dept.*

Reader Service Card: Circle No. 80

INVENTIONS AND INVENTORS

Annealing and Tempering

Annealing Glass. Patent No. 2,952,097. Original application May 18, 1953, now Patent No. 2,774,190. Divided and this application January 24, 1956. Issued September 13, 1960. Five sheets of drawings; none reproduced. Assigned to Pittsburgh Plate Glass Co. by Florian V. Atkeson.

This invention relates in general to the annealing of glass and more specifically to apparatus for substantially uniform control of the temperature of the cooling glass as it passes through the annealing range in order to obtain the glass characteristics desired.

The purpose is to produce glass which has a minimum of transverse curvature and optimum optical characteristics, resulting from more uniform thickness of the sheet, a substantially uniform over-all residual stress pattern and improved cutting characteristics.

It has been found that the residual stress present in annealed glass is a function of the time the glass is kept within its annealing temperature range and the manner in which the glass is cooled through the range. There is an optimum range of residual stress in glass which renders the glass most suitable for cutting. High stress values tend to increase cutting difficulties by increasing the tendency of a running fracture to depart from a score line made by a cutting tool. Stress values which are too low indicate the glass it too well annealed, and the latter is said to be dead and difficult to cut.

In order to achieve the objects of the present invention, the temperature of a sheet of glass is rapidly and uniformly cooled to the upper limit of the annealing range by a plurality of coolers and differential coolers, the latter being described as including water cooled pipes and heating elements. The cooling effect of the latter is regulated by means of electric circuits. Each circuit utilizes a thermo-responsive element trained on a portion of the surface of the rising glass sheet to control the current flow in a resistance heater by means of an arrangement that may include a saturable reactor and a feed back circuit.

By dividing each horizontal set of thermoresponsive elements into three independently controlled circuits, the temperature of the central portion and each end portion of the vertically rising sheet surfaces can be independently controlled on each side of the vertically drawn sheet. This maintains a very close control of the temperature of the cooling glass. The temperature gradient from edge to edge and from surface to surface of the glass sheet can be kept at a minimum. Also, the height above the molten glass both at which the vertically drawn sheet reaches a predetermined temperature corresponding to the top of the annealing range is regulated.

The thermo-responsive elements are constructed with specially designed filters responsive only to the 4 to 8 micron wavelength band of infra-red radiation. At this wavelength glass is opaque so that the thermo-responsive element trained on one surface area of the glass "reads" the temperature radiated by the glass surface only and is not responsive to heating elements located on the other side of the vertically drawn glass sheet.

There were 6 claims and 12 references cited in this patent.

Glass Compositions

Ultraviolet Light Absorbing Glass. Patent No. 2,974,052. Filed July 11, 1960. Issued March 7, 1961. One sheet of drawings: not reproduced. Assigned to Owens-Illinois Glass Co. by Frank R. Bacon and Carroll J. Billian.

The present invention relates to glasses which absorb ultraviolet radiation and short-wave radiation within the visible spectrum.

The invention is of utility in the manufacture of glass bottles, jars, and other containers used for the packaging of food, beverage, and pharmaceutical products which are detrimentally affected by undesirable photochemical effects produced by such radiation.

The preferred compositions of the invention can be summarized as follows.

Components	Per cent by Weight
SiO_2	60 —75
R_2O_3 (total)	0.1 —10.0
Al_2O_3	0.1 — 9.5
Fe_2O_3	0.020— 0.20
CaO	6 —12
BaO	0 — 1.0
B_2O_3	0 — 5
MgO	0 — 6
Na_2O	10 —20
K_2O	0 — 1
Cr_2O_3 (total)	0.1 — 0.3
CrO_3	0.005— 0.070
CoO	0.002— 0.008

There were three claims and the following references cited in this patent.

United States Patents

2,699,399, Armistead, Jan. 11, 1955.

Other References

The Glass Industry, "Chemistry of Colored Glass", April 1937, page 117.

Tooley: *Handbook of Glass Manufacture* (1953), published by Ogden Publishing Co., page 250, Table IXB-VIII.

Glass Wool and Fibers

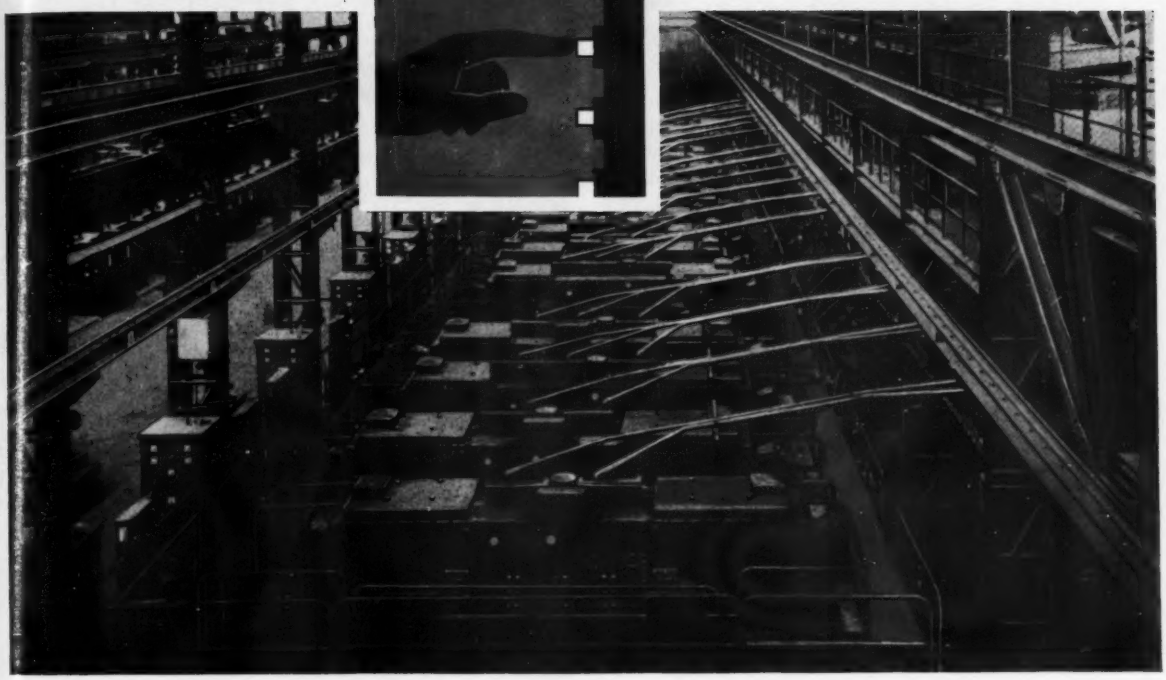
Pressurized System for Producing Fibers. Patent No. 2,974,359. Filed February 15, 1955. Issued March 14, 1961. One sheet of drawings; none reproduced. Assigned to Owens-Corning Fiberglas Corp. by Walter G. Van Der Hoven.

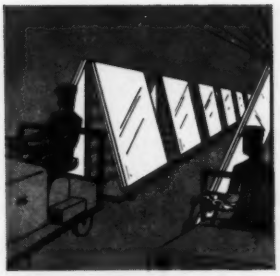
This invention is related to the production of fibers and more particularly to a system for production of fibers of thermoplastic or heat softenable material in which the fibers are attenuated from the outlet orifices of a feeder containing molten material under pressure.

A new system for supplying raw material to a melting and feeder unit is provided, wherein the raw material introduced to the molten body will melt more readily at the body surface.

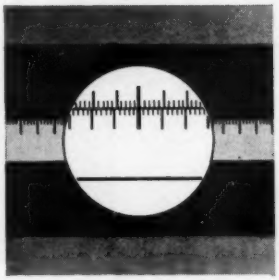
(*Continued on page* 540)

automation





productivity



precision

Réalisations RICHARD

The DUPLEX GRINDING and POLISHING MACHINES grind and polish glass from 1/8", used in Laminated Glass for the motor car industry, up to the greatest thickness.

Their conception guarantees :
- the highest degree of efficiency,
- the highest productivity,
- complete automation.

The precision in their construction ensures for Plate Glass unequaled optical properties :
- Optical power : smaller than 1 millidiopter
- Angle between both faces : smaller than 10 seconds
- Difference of thickness in any one plate : smaller than $\frac{2}{1000}$ inch (0.002 inch)

SOCIETE ANONYME DES
ATELIERS DE CONSTRUCTION DE LA MEUSE
ESTABLISHED 1835
SCLESSIN-LIEGE (BELGIUM)

•CALENDAR•
OF COMING EVENTS

September 13-15

AERONAUTICAL SYSTEMS DIV., AIR FORCE SYSTEMS COMMAND. Technical symposium. J. J. Niehaus and H. A. Johnson, Material Central, program chairmen. Phoenix, Ariz.

September 25-28

INTERNATIONAL BUILDING EXPOSITION AND CONGRESS. New York Coliseum, New York, N.Y.

September 26-29

UNION SCIENTIFIQUE CONTINENTALE DU VERRE (USCV). Third symposium; promoted in cooperation with the Glass Experimental Station at Murano, Italy. The meeting will be devoted to the study of the mechanical properties of glass and means of improving them. Florence, Italy.

October 2-4

AMERICAN GAS ASSOCIATION. Annual convention, Dallas, Tex.

October 10

ACS PITTSBURGH SECTION. A joint meeting to be held with the Pittsburgh Ceramic Association. Pittsburgh, Pa.

October 11-13

ACS GLASS DIVISION. Fall meeting. H. E. Simpson, program chairman. Bedford Springs, Pa.

October 16-19

INTERNATIONAL CONGRESS ON VACUUM TECHNOLOGY. Sheraton Park Hotel, Washington, D. C.

October 25-28

ACS 14TH PACIFIC COAST REGIONAL MEETING. Jack Tar Hotel, San Francisco, Calif.

November 30, December 1

22ND ANNUAL CONFERENCE ON GLASS PROBLEMS. University of Illinois, Urbana, Ill.

February 11-14, 1962

CANADIAN CERAMIC SOCIETY. Diamond Jubilee Meeting. Royal Connaught Hotel, Hamilton, Ontario, Canada.

April 29-May 3, 1962

ACS 64TH ANNUAL MEETING. Roosevelt, Commodore, and Biltmore Hotels, New York, N. Y.

July 8-14, 1962

SIXTH INTERNATIONAL CONGRESS ON GLASS. Washington, D. C.

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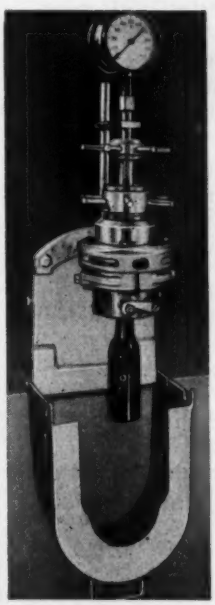

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CURRENT STATISTICAL POSITION OF GLASS

Employment in the glass industry during May, 1961 was as follows: *Flat Glass*: a preliminary figure of 23,300 for May, 1961, indicates an increase of 4.9 per cent over the adjusted figure of 22,200 for April, 1961. *Glass and Glassware, Pressed and Blown*: an increase of 1.7 per cent is shown by the preliminary figure of 88,000 reported for May, 1961, when compared with the adjusted figure of 86,500 reported for April, 1961. *Glass Products Made of Purchased Glass*: the preliminary figure of 12,700 given for May, 1961, is 0.7 per cent over the adjusted figure of 12,600 reported for April, 1961.

Payrolls in the glass industry during May, 1961, were as follows: *Flat Glass*: an increase of 10.8 per cent is shown in the preliminary $12,628,996.75 given for May, 1961, when compared with April's $11,397,861.17. *Glass and Glassware, Pressed and Blown*: an increase of 2.6 per cent is shown in the preliminary $36,147,619.20 given for May, 1961, when compared with the previous month's adjusted $35,205,386.69. *Glass Products Made of Purchased Glass*: a preliminary figure of $4,238,341.28 was reported for May, 1961. This is an increase of 3.9 per cent when compared with the adjusted figure of $4,077,760.30 for April.

Glass Container Production based on figures released by the Bureau of Census, Industry Division, was 15,243,000 gross during June, 1961. This is an increase of 7.9 per cent over the previous month's production figure of 14,127,000 gross. During June, 1960, glass container production was 14,845,000 gross, or 2.6 per cent less than the June, 1961 figure. At the end of the first six months of 1961, glass container manufacturers have produced a preliminary total of 82,886,000 gross. This is 2.5 per cent more than the 80,837,000 produced during the same period in 1960.

Glass Container Shipments during June, 1961, came to 15,785,000 gross, an increase of 15.6 per cent over the May figure of 13,656,000 gross. Shipments during June, 1960, amounted 14,352,000 gross or 9.1 per cent less than June, 1961. At the end of the first six months of 1961, shipments have reached a preliminary total 81,032,000 gross. This is 4.9 per cent more than the 77,228,000 gross shipped during the same period of the previous year.

Stocks on Hand at the end of June, 1961, came to 21,657,000 gross. This is 2.8 per cent less than the 22,273,000 gross on hand at the end of May, 1961, and 4.4 per cent more than the 20,748,000 gross on hand at the end of June, 1960.

GLASS CONTAINER SHIPMENTS
(All Figures in Gross)

Narrow Neck Containers

	June, 1961
Food	1,402,000
Medicinal and Health Supplies	1,286,000
Chemical, Household and Industrial	891,000
Toiletries and Cosmetics	851,000
Beverage, Returnable	1,372,000
Beverage, Nonreturnable	384,000
Beer, Returnable	414,000
Beer, Nonreturnable	2,775,000
Liquor	946,000
Wine	414,000
Subtotal (Narrow)	10,735,000

Wide Mouth Containers

Food	*4,051,000
Medicinal and Health Supplies	388,000
Chemical Household and Industrial	156,000
Toiletries and Cosmetics	236,000
Dairy Products	118,000
Subtotal (Wide)	*4,949,000
Total Domestic	15,684,000
Export Shipments	*101,000
TOTAL SHIPMENTS	*15,785,000

* This figure includes fruit jars, jelly glasses, and packers' tumblers.

GLASS CONTAINER PRODUCTION AND INVENTORY
(All Figures in Gross)

		Production June 1961	Stocks June 1961
Food, Medicinal and Health Supplies; Chemical, Household and Industrial; Toiletries and Cosmetics.	Narrow Neck	4,676,000	7,341,000
	Wide Mouth	*5,117,000	*7,235,000
Beverage, Returnable		1,012,000	2,425,000
Beverage, Nonreturnable		467,000	686,000
Beer, Returnable		290,000	513,000
Beer, Nonreturnable		2,375,000	1,142,000
Liquor		909,000	1,537,000
Wine		397,000	778,000
Dairy Products		117,000	296,000
TOTAL		*15,243,000	*21,657,000

* This figure includes fruit jars, jelly glasses, and packers' tumblers.

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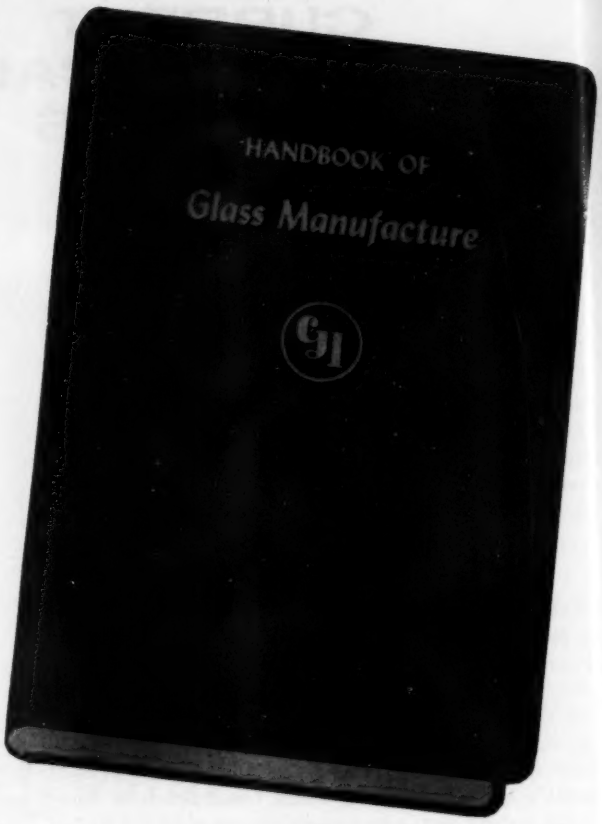

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GREAT MOMENTS IN GLASS

(*Continued from page* 498)

Wheels of different diameters determine the width of the cut. The result is a design that appears to be in bold relief while actually it is ground into the glass. The tall goblet (Fig. 2a and 2b) is a good example of intaglio engraving and dates from the Seventeenth Century, soon after wheel engraving was first used on potash-chalk glass.

Lead Glass

At about the same time that Continental Europe made this contribution to the history of glass technology, England was also striving to make a glass that would surpass Venetian products. For 100 years after a Venetian glassmaker set up a factory in England in 1575, the English had a glass industry which used not only Venetian styles and formulas but occasionally imported Venetian raw materials. This dependence on Venice was the major factor which led to the financing of glass research by the affluent Glass Sellers Co. In 1673 the services of a competant glassmaker, George Ravenscroft, were engaged to carry out experiments in the hope of making, in the words of his petition, "a particular sort of Cristaline resembling Rock Cristall."

For 3 years Ravenscroft attempted many combinations of ingredients. One attempt included using English calcined and ground flints as the silica ingredient; hence the term "flint glass," which is still used today. The early experiments failed because of the use of excessive amounts of alkali, probably intended to make the flint silica fuse more readily. This produced "crizzling," an eventual leaching out of the alkali due to atmospheric moisture. To remedy the crizzling, Ravenscroft decided to introduce lead oxide into the batch. This was probably suggested to him by passages in the English translation of Antonio Neri's classic handbook *L' Arte Vetraria,* published in London in 1662. First used in small quantities, the lead oxide, called litharge, was increased to a sizeable proportion of the mixture. In 1676, Ravenscroft's trials were successful, and the justly famous English "glass-of-lead" was the result.

Typical of the products made by Ravenscroft after lead glass was put into regular production is the goblet shown in Fig. 3. This sturdy object was made in his Savoy glasshouse in London in 1676 or 1677, and bears a raven's head glass seal indicating that the goblet is made of glass using the improved, noncrizzling formula. It points out the novel characteristics of Ravenscroft's discovery. First, lead glass was heavier and could not be blown as thinly or as intricately as the Venetian-type soda glass. As a result, simple substantial forms became more and more common as the English developed a native glassmaking style. Secondly, the new lead glass had a deep inner brilliance which required very little decoration to show it off. After engraving had been tried and largely discarded by the English, prismatic

(*Continued on page* 536)

NEW BOOKS

MANAGERIAL PERFORMANCE STANDARDS, by Virgil K. Rowland, Assistant to the President, The Detroit Edison Co. American Management Association, 1515 Broadway, New York 36, N. Y. 192 pages. $3.50

This is the fourth publication in the AMA Handbook series on basic skills and tools of management. It deals with the setting of standards for executive performance and focuses sharply on the dynamic relationship between a manager and his subordinates, and a manager and his superior.

Mr. Rowland feels that the weakest link in the management chain of communications is the "man-to-boss" relationship, and an improvement here means improvement in performance and employee relations. How this link can be strengthened is the subject of this book.

The Handbook describes a technique for setting standards for executive performance. A step-by-step plan is provided and actual transcripts of standard-setting sessions are analyzed. The author shows how, through group discussions and private interviews, superior and subordinate work together to set standards.

STUDY OF ULTRA HIGH TEMPERATURES, by A. V. Grosse and C. S. Stokes, Research Institute of Temple University for Wright Air Development Center, U. S. Air Force. Order PB 161460 from Office of Technical Services, U. S. Department of Commerce, Washington 25, D. C. 26 pages. $1.00

This is the final report covering a four year study of various chemical and physical phenomena at temperatures up to 5000°K. It summarizes the work reported in previous technical notes.

THIN METAL FILMS AS CORROSION INDICATORS, by R. B. Belser and F. E. Hankinson, Engineering Experiment Station, Georgia Institute of Technology, for Wright Air Development Center, U. S. Air Force. Order PB 151974 from Office of Technical Services, U. S. Department of Commerce, Washington 25, D. C. 56 pages. $1.50

Report of an Air Force research project which evaluated thin metal films placed on glass substrates as corrosion indicators, with possible use for the protection of packaged materials.

The corrosion behavior of 614 iron, iron-copper, and manganese thin films were observed in sealed test chambers at 25°C and 70 per cent relative humidity. Electron diffraction examinations of films stored in both chambers and in room air revealed that the iron films, cleaned by a chromic acid detergent and an alcohol rinse did not show any sign of corrosion in 60 days; manganese films ranging in thickness from 250 to 1500 Angstroms showed a corrosion rate related to their thickness; films thicker than 1500 Angstroms did not corrode appreciably.

The report's conclusion is that a combination of sensitized and unsensitized iron film elements may prove useful as corrosion indicators for the protection of various packaged materials, but further research is necessary before any definite application is possible.

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GREAT MOMENTS IN GLASS

(*Continued from page* 535)

cutting became popular in the second half of the Eighteenth Century.

Cutting took full advantage of the light-dispersing quality of the lead glass, and the technique of cutting deep geometric patterns almost displaced every other kind of decoration in the late Eighteenth Century in England and Ireland. Typical of Irish work at its best is the sweetmeat dish (Fig. 4) which displays the high refraction index of the object.

The present-day quality of European and American "crystal" glass is based on the use of variations of Ravenscroft's formula, a contribution which permitted great scientific and artistic advances in glassmaking.

AMERICAN SCIENTIFIC GLASSBLOWERS

(*Continued from page* 504)

Training Methods for Glassblowers

By C. M. DeWoody, Ace Glass Inc., Vineland, N. J.

In 1959, Salem County, N. J., established a Vocational-Technical Institute which offers 2-year diploma courses to high school graduates at a nominal tuition of $50.00 per year for residents and $150.00 per year for nonresidents of the county. The courses are classified as public education and come under the supervision of the New Jersey Department of Education. Standard college requirements are necessary for admission.

The curriculum covers the following subjects.

First Year (18 weeks)	Hours per Week
Scientific Glassblowing	15
Industrial Chemistry	4
Mathematics	4
Blueprint Reading and Drawing	3
Technical English	4
Second Year (18 weeks)	
Scientific Glassblowing	15
Physics	6
Mathematics	4
Technical English and Report Writing	2
Machine Shop	3

The total 540 glassblowing hours may be applied against the 7000 required for apprenticeship in those plants which are committed to the union guild system.

The success of this course has, to date, been better than expected, and evening courses are now in the planning stage. Two basic courses are contemplated, the first an elementary one designed for chemists, laboratory technicians, science teachers, and similar personnel. The second course is intended to help the glassworker who is making perhaps only one or two items per day and wishes to improve his technique. In this course the student's ability and previous knowledge will be ascertained, and classes will then be individually plotted for him to round out his education. The project method most likely will be used so that progress can be realized

in definite steps. Apprentices may also enroll in this type of course to shorten apprenticeship in terms of years.

It will be noted that the public education program is designed to combine the best features of the guild and academic methods, giving well-rounded basic training to small groups where such training can be advantageous, and individual training when specialized and difficult techniques of manipulation are to be taught. The training in primary fundamentals is standardized so that any employer, upon hiring such a person, knows that his training up to that point is satisfactory. The student himself has the proper background for advanced training, a background which is not only accepted, but endorsed, by large manufacturing groups. Therefore, the job opportunities of the graduate are widened. Furthermore, a foundation is formed upon which a professional glassblower status can be built for scientific apparatus workers. This presents the opportunity for advancement to those who feel the need for more professional training and who otherwise might not have the opportunity.

The Use of Devitrifiable Solder Glass in Experimental Vacuum Devices

By K. D. Earley and D. E. George, General Telephone and Electronics Lab.

One of the most intriguing and challenging contributions of recent years to glass working is that of devitrifiable solder glasses. These are finely divided frits which, upon proper heat treatment, melt, flow, and cure into glass-bonded ceramic bodies. They can be used to cement together a number of materials with less stringent thermal expansion matches than glass-to-metal seals.

The fritting technique is a simple one: a slurry is suspended in nitrocellulose lacquer and applied to parts by flowing, dipping, or brushing; the coat is then dried and the parts are fired together. The advantages of the technique immediately become evident; the curing temperature of the frit is far below the deformation temperature of the glass, so control of starting geometry is assured. Close-tolerance work is simplified, and shapes impossible to make by all but the most experienced glassblower are readily achieved.

Most of the work at the Bayside laboratories has been with Corning's No. 95 and No. 45 Pyroceram. No. 95 cement matches soft glasses and their sealing metals; No. 45 cement matches the alumino-silicate glasses, molybdenum and tungsten. Both cements have a curing range, but almost all of the work done at these laboratories has been within rather narrow ranges of temperatures for each frit. No. 95 cement has been heat-treated at 440°C for 1 hour and at 470°C for half an hour. No. 45 cement has been cured at 750°C for 60 minutes and at 760°C for 30 minutes.

Two types of furnaces have been used for the curing operation. The first is a standard noncirculating top-loading floor model. The second is a vertical-wound

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serrated quartz glass tube contained in a quartz glass holder. This type of furnace is used for tubular seals and permits zone heating. For temperatures below 500°C the windings are nichrome wire; for temperatures above 500°C a platinum winding is used.

The application of fritting techniques has been almost entirely in low-power microwave tubes. Many nearly insurmountable problems of construction have been solved by the use of these seals.

To illustrate the usefulness of certain techniques, several devices were compared with conventional flame sealing. The velocity-sorting detector consists of an electron source, a slow-wave structure (helix), an electron-optical velocity detection system, and finally, a collector. The problem was to seal the electron source and input coax line at one end of the tube, and the detector, collector, and output coax at the other end. This problem was further complicated by the fact that the gun, helix, and detector do not share a common mount, but are isolated from one another. Obviously, the problem of alignment between gun, helix, and detector is critical. All glass parts in this tube are fabricated from soft glass, and No. 95 cement is used for the seals. The electron gun end is fritted into place, and the other parts placed on a line-up mandrel which passes through the detector and helix, and protrudes into the gun to within 1/16 in. of the cathode. The order of assembly from then on is the detector system, the two coaxes, and finally the collector, after the line-up mandrel is removed.

The techniques described were not meant to compete with production methods, but it is believed that the basic principle could be adapted to production in some cases.

The Technological Training of European Lampworkers

By Anthony J. Hawkins, State University of New York, College of Ceramics, Alfred University, Alfred, N. Y.

An inquiry into European methods of training scientific glassblowers was conducted as part of the author's 1960 summer vacation. The material is mainly concerned with training as practiced in Great Britain, Holland, and West Germany, and includes some comments on the industry throughout Western Europe.

As a rule, the European scholastic system is similar to its North American counterpart for students up to the age of 11 (or a little earlier in some cases). At this crucial time, the student body is divided into two distinct groups. About 25 per cent will be given a formal education directed toward entrance into a college or university; the remaining 75 per cent will attend a so-called secondary school in which they will receive teaching and discipline directed toward local interests and well-rounded development.

Since the Second World War, many operations formerly done by hand have been mechanized. Perhaps, as in other industries that have expanded, the common laboratory article will eventually be produced entirely

by mass-production methods, This, naturally, creates a demand for designers or technologists who know what can be achieved with basic material in terms of functional use and potential.

Already individual research establishments require technical personnel who can plan, erect, and initially operate various complex systems. To the author it seemed highly desirable that there should exists in the United States an institution where all phases of glasswork could be taught. There exist many schools for the practice of ceramics and pottery, but apparently none for glassware.

Radiation Damage in Glass

By R. Spencer and M. Yamovsky, Tung-Sol Electric Inc. and *L. Kaplan,* U. S. Army Signal Research and Development Lab.

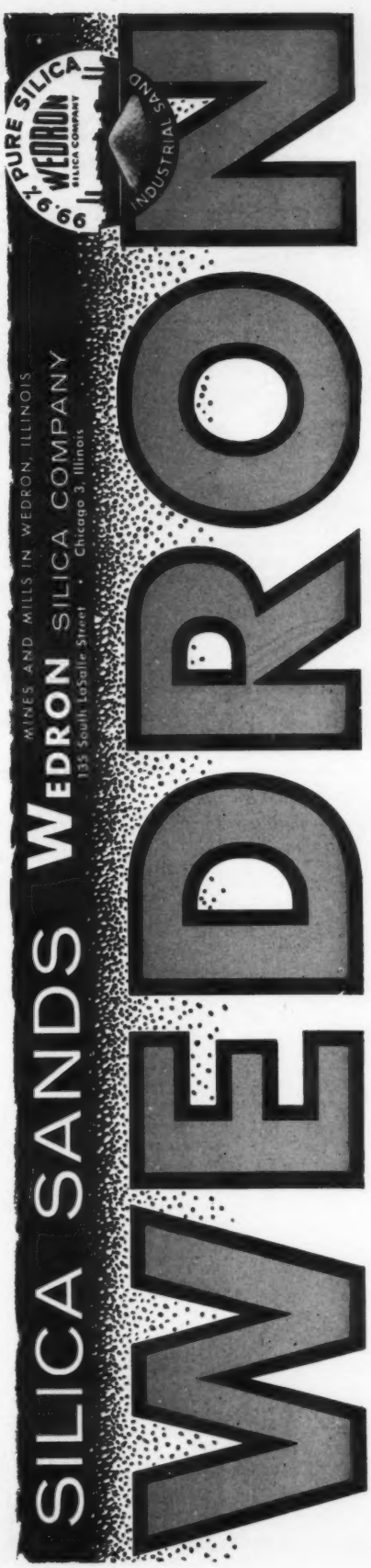
The three effects of radiation on borosilicate glass were described as actual glass fracture, gas evolution, and discoloration. Although the degree of discoloration did seem to be related to the likelihood of glass fracture, discoloration itself did not impair the usefulness of electron tubes, with the possible exception of photosensitive tubes. For this reason the study was directed toward the problems of glass fracture and gas evolution.

It appeared evident that all glasses will discolor in varying degrees when subjected to integrated thermal neutron fluxes in the order of 10^{16}nvt. It was found that Kimble's EE-2 boron-free hard glass and such soft glasses as G-8 and G-12 showed less evidence of gassing when exposed to certain fluxes. Ionization gauges in nonex, alumino-silicate, and lime glasses have shown that at 0.4 by 10^{16} nvt the increase in gas pressure is not more than 5 microns.

The experimental evidence appeared to bear out the premise that the B^{10} isotope is instrumental in causing radiation damage to the hard glasses. Boron-free glasses exposed to integrated fluxes of up to 10^{18}nvt gave no indication of fracture, while some borosilicate glasses shattered at exposures as low as 10^{16}nvt. Calculations showed that only about 0.4 per cent of the total boron content of nonex is depleted at 10^{17}nvt. It was, therefore, likely that fracture is *not* due solely to the depletion of boron, but may also be due to structural changes caused by the intense ionization produced along the paths of the $_3Li^7$ nucleus and the α-particle.

The increase in gas pressure in irradiated enclosures was probably due to out-gassing of the glass bulb caused by thermal spikes when the α-particle and $_3Li^7$ nucleus dissipate the 2.8-mev reaction energy. Unfortunately, the exact temperature that the various bulbs attained in the reactor was not determined. Some samples were painted with special temperature-indicating paints, but the paints themselves remained so radioactive after exposure that the samples could not be examined. Earlier measurements by the Brookhaven staff showed that the temperature would be in the neighborhood of 150°C.

It is unlikely that α-particles themselves escape in sufficient number into the vessel to form enough helium



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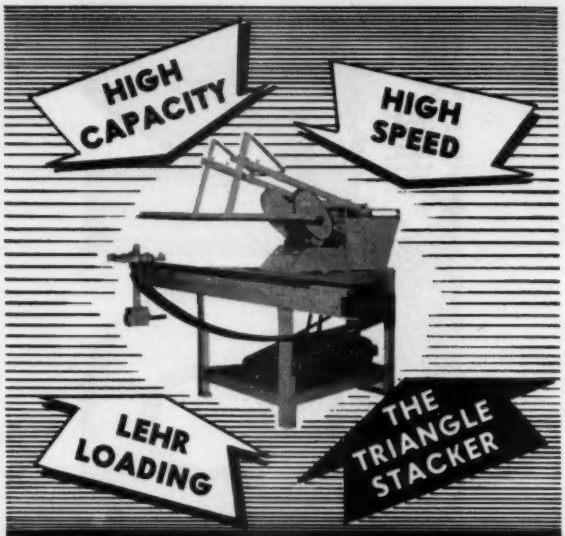

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atoms to account entirely for the increase in gas pressure. Calculations showed that in nonex after an exposure of 4 by 10^{15}nvt, at the most, only 0.002 per cent of the increase in gas pressure could be accounted for by the formation of helium atoms from α-particles.

Although special boron-free hard glasses such as Kimble EE-2 and Corning 1715 are able to withstand extremely high neutron fluxes, they have been found to be very difficult to work. It would be desirable to have borosilicate glasses without the inclusion of the B^{10} isotope, but present methods of separating the B^{10} isotope from B^{11} are so expensive as to make this impractical. Further developments by glass manufacturers may result in a boron-free hard glass with working properties similar to the present borosilicate glasses. It was also suggested that various shielding materials such as boron-steel alloys or cadmium foil might be used to protect present hard glass electron tubes from thermal neutron bombardment.

(To be concluded next month)

INVENTIONS AND INVENTORS

(*Continued from page* 528)

The system for supply of raw material is automatically maintained at a limited stacked height such that the bottom-most portions of the stack will not be pressed unduly below the level of the molten body.

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Circle No. 34

A feature of the invention is its adaptability to automatic uniform feed of raw material to a feeder and consequent establishment of operational stability and production of fibers of more uniform properties than were heretofore possible in such systems.

There was one claim and the following references cited in this patent.

United States Patents

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Foreign Patents

429,795, Great Britain, June 6, 1935.

Miscellaneous

Electrically Conductive Windshield. Patent No. 2,944,926. Filed February 6, 1956. Issued July 12, 1960. Five sheets of drawings; none reproduced. Assigned to Libbey-Owens-Ford Glass Company, by Romey A. Gaiser.

It is an aim of this invention to equip automobile windshields with a transparent film or coating capable of conducting electrical energy and operating to remove accumulations of ice, frost, or fog by internal heating of the glass. In order to provide an electrically conducting film on a surface of one or both of the glass sheets or plates, it has been found advantageous to carry out the filming operation in advance of the bending operation or when the sheets or plates are perfectly flat.

This filming operation involves the application of strips of fusible material in spaced areas and preferably along the opposed margins of a glass sheet and in substantially parallel relation, heating the glass sheet to substantially its point of softening and simultaneously fusing the fusible material to form electrodes or bus bars upon the glass, and then spraying the surface of the heated glass sheet containing the electrodes with a suitable material, such as a tin halide, to form upon the sheet a transparent, continuous, though extremely thin, electrically conducting coating of tin oxide. During installation of the completed windshield, the electrodes are connected by suitable leads to a source of controlled electrical current to supply the conducting film. A fired-on silver flux that may be used to form the electrodes may consist of 65.6 per cent silver, 7.8 per cent flux, 18 per cent organic liquid binder, and 8.54 per cent thinner. After filming, the glass blank is adapted to be bent to the desired curvature.

There were 11 claims and the following references cited in this patent.

United States Patents

2,557,983, Linder, June 26, 1951; 2,614,944, Lytle, Oct. 21, 1952; 2,725,320, Atkeson et al., Nov. 29, 1955.

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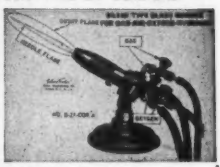

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